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CONTINUED ON PAGE 3

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ANNALS of SURGERY

VOL. LXVIII SEPTEMBER, 1918 No. 3

PRELIMINARY REPORT OF A METHOD FOR ESTIMATING IN VIVO THE GERMICIDAL ACTIVITY OF ANTISEPTICS

By Joseph A. Perkins, M.D.

LIEUTENANT M. R. C. U. S. A.

During the past month at the Pennsylvania Hospital we have been trying to develop a method by which we could estimate the germicidal activity of antiseptics in infected wounds.

The method of estimating and graphically recording the bacterial contents of a wound with the microbe charts works out well clinically, but the results are, at best, a very crude determination, because the area of the smear examined (counting 10 or 20 fields through a $^1/_{12}$-inch oil-immersion lens) contains a very small proportion of the microbes removed from the wound on the platinum loop. Be the smear as smooth and even as is humanly possible to make it, the margin of error is still very large. With a view to reducing this margin of error we have been culturing the wounds, counting the number of colonies and plotting curves as in the microbe charts mentioned above. Admitting that there is still much to be desired, in that the size of the drop obtained on the loop is still a variable quantity, we feel that we have a very much truer estimation of the bacterial content of the wound than when using the smear method.

In order to reduce as far as possible the element of the personal equation, the work has been done by one man. The inoculations were made from the same part of the surface of the wound, one definite spot being selected and used throughout; the attempt was made to get a uniform-sized drop; the same platinum wire loop was used each time. The drop obtained was inoculated at the bedside in 2 c.c. of plain bouillon, the bouillon suspension, undiluted, was immediately poured over an agar-agar plate, which was then covered and turned upside down and marked with the patient's number, the number of the culture, and the time the culture was taken. The plate was then taken to the laboratory and placed in an incubator and kept at thirty-seven degrees C. At the end of twenty-four hours the colonies were counted, macroscopically, and recorded.

The first case, an incised carbuncle with several discharging sinuses, gave, as you will see on Fig. 1, rather irregular curves. We believe that as the patient turned about in bed during the day some sinus discharged pus and bacteria which ran over the area from which the inoculations were taken, a point on the surface of the bottom of the wound and in the centre of the star, reinoculating that area and, therefore, giving a very

distorted idea of the progress of disinfection. It does show, however, after dressing with dichloramine-T, the initial drop or practical sterilization of the wound surface followed by the gradual reappearance of organisms, the germicidal activity lasting at least sixteen hours in the first curve and fourteen hours in the second.

Two other cases were then chosen, each with a localized infection and without any demonstrable sinuses.

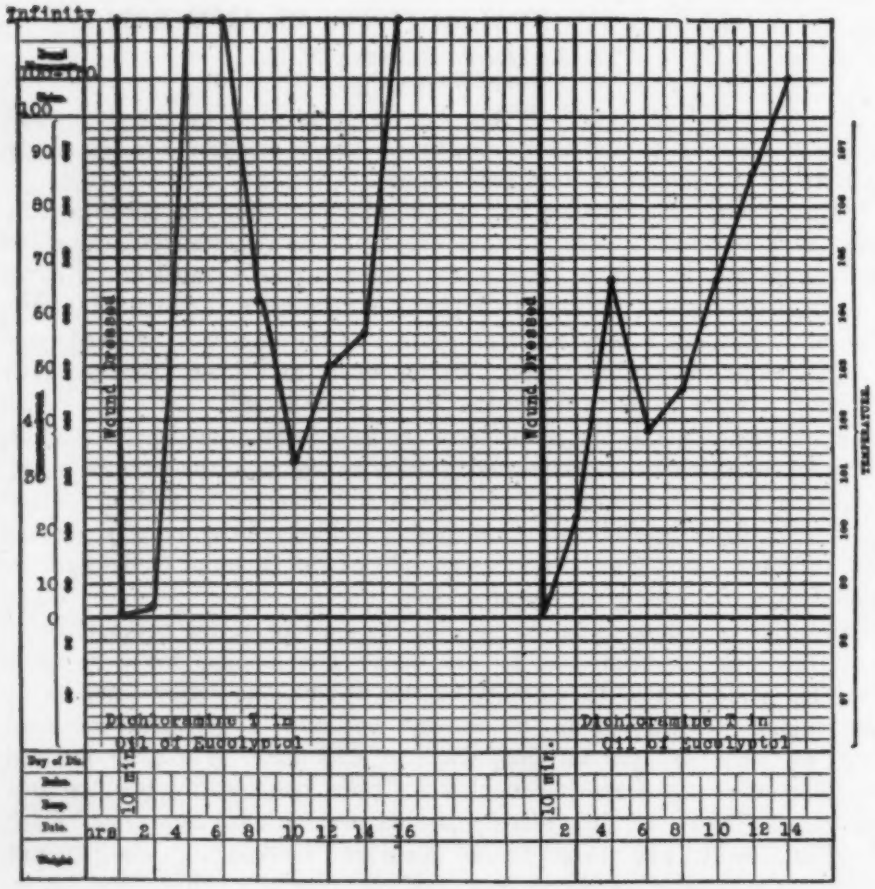
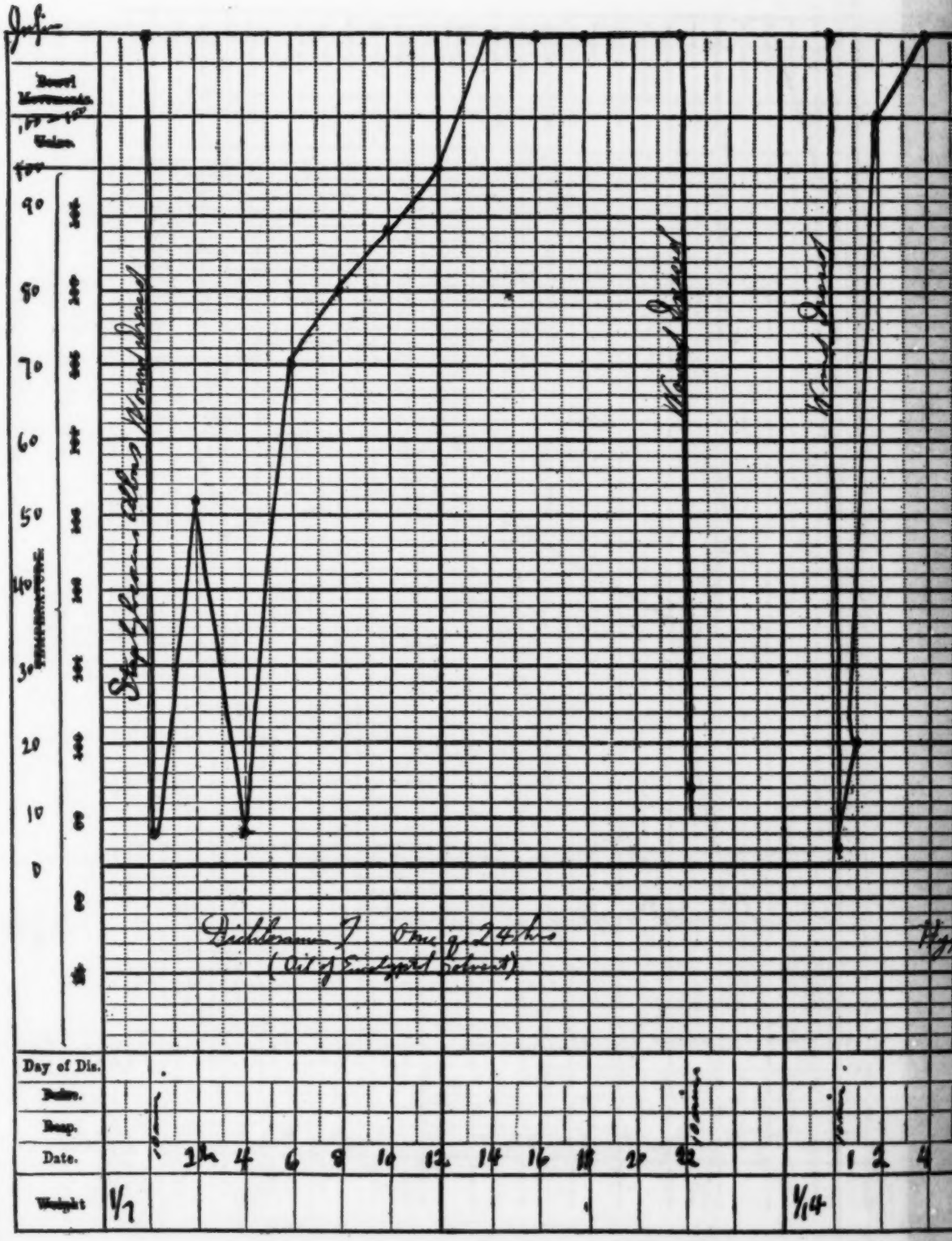


FIG. 1.

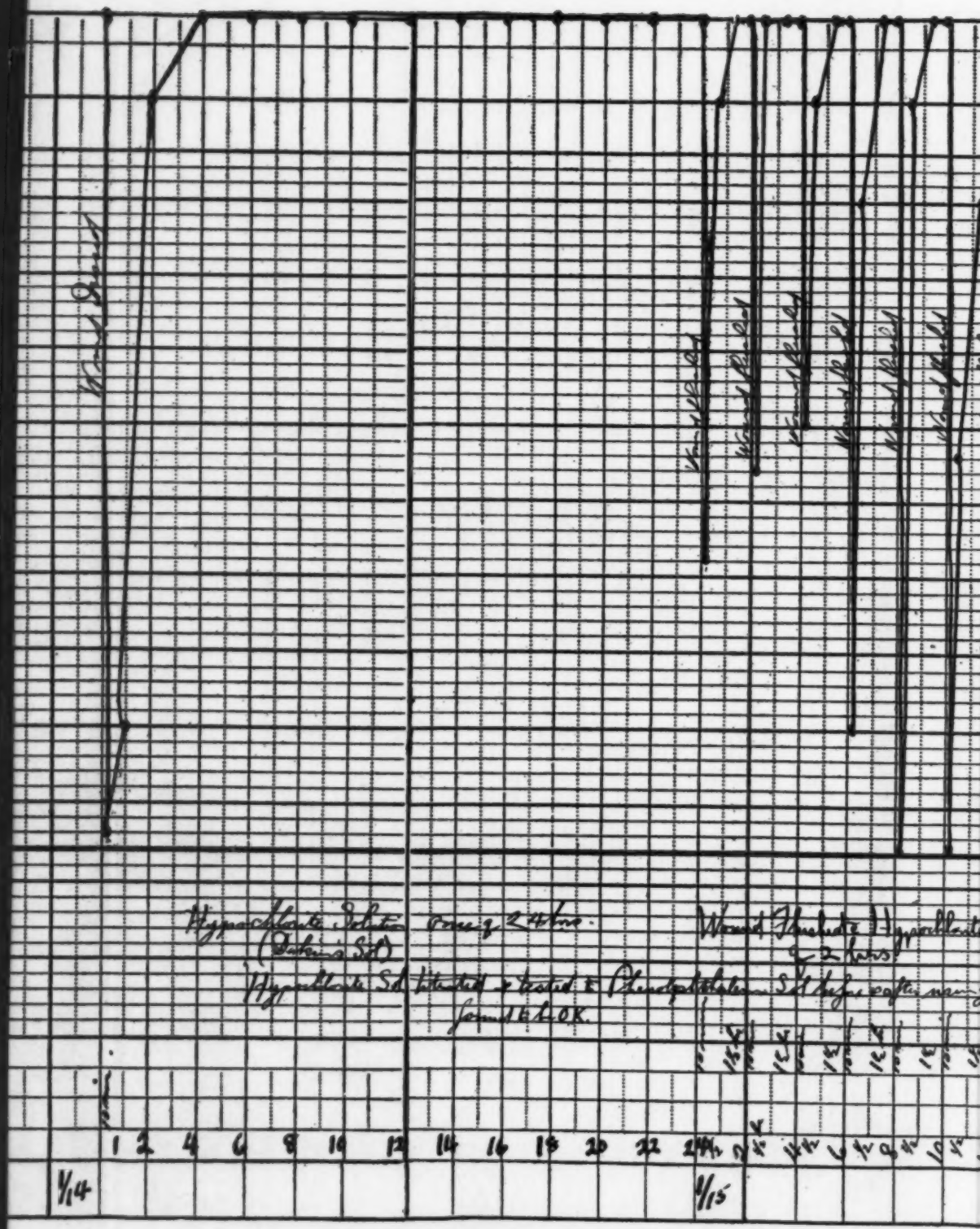
The first, an Italian laborer twenty-seven years old, admitted December 22, 1917, sent in from Out-patient Department with diagnosis of chronic osteoperiostitis of the right tibia.

Three years ago the patient had had an operation upon this region of the leg, the wound healed quickly and the patient had had no further trouble until the present illness started two weeks before admission. The X-ray taken from dispensary showed a localized osteomyelitis and probable beginning sequestrum.


Bowel Movements
Urine
90
80
70
60
50
40
30
20
10
0
Day of Dis.
Pulse.
Resp.
Date.
Weight
1/1
1/4

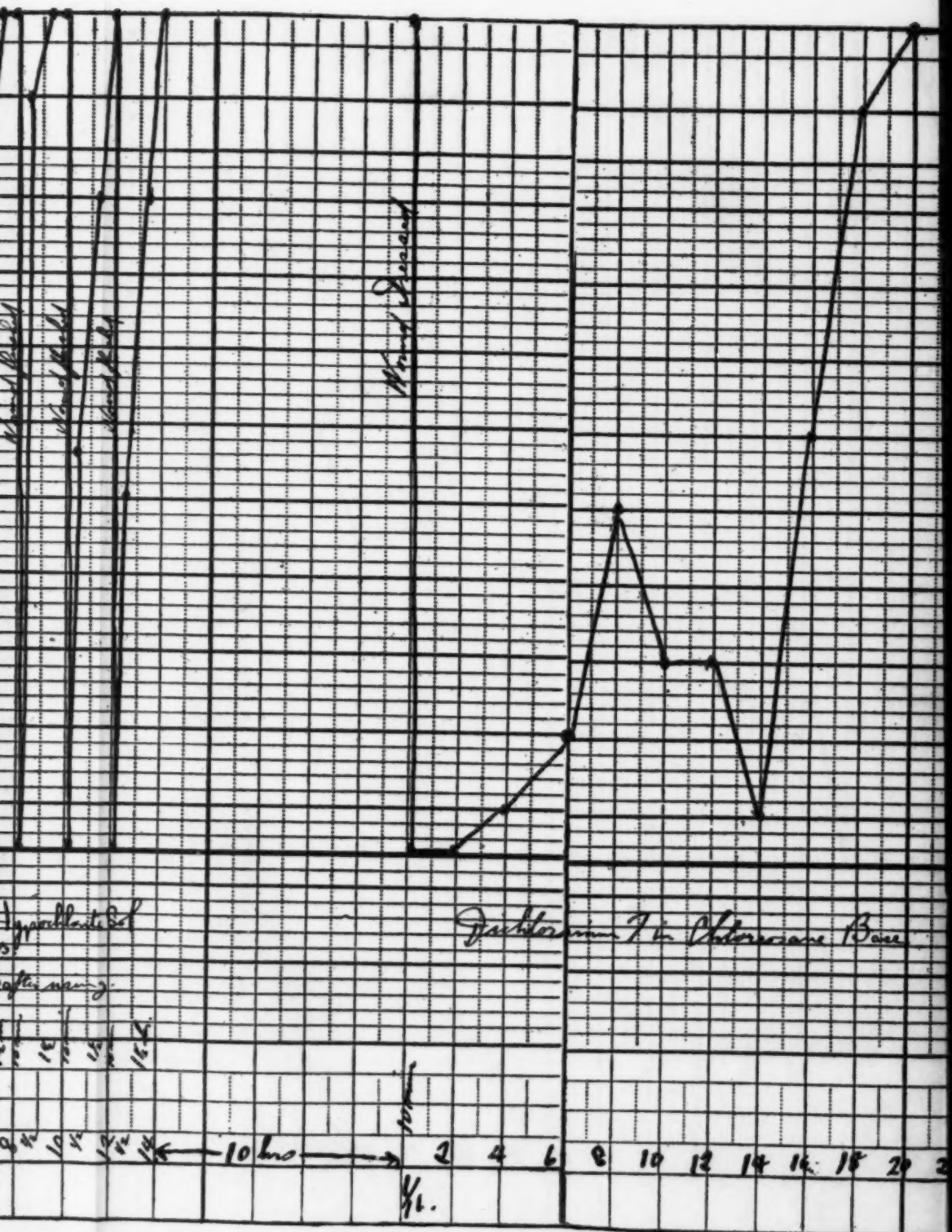
First curve

FIG. 2

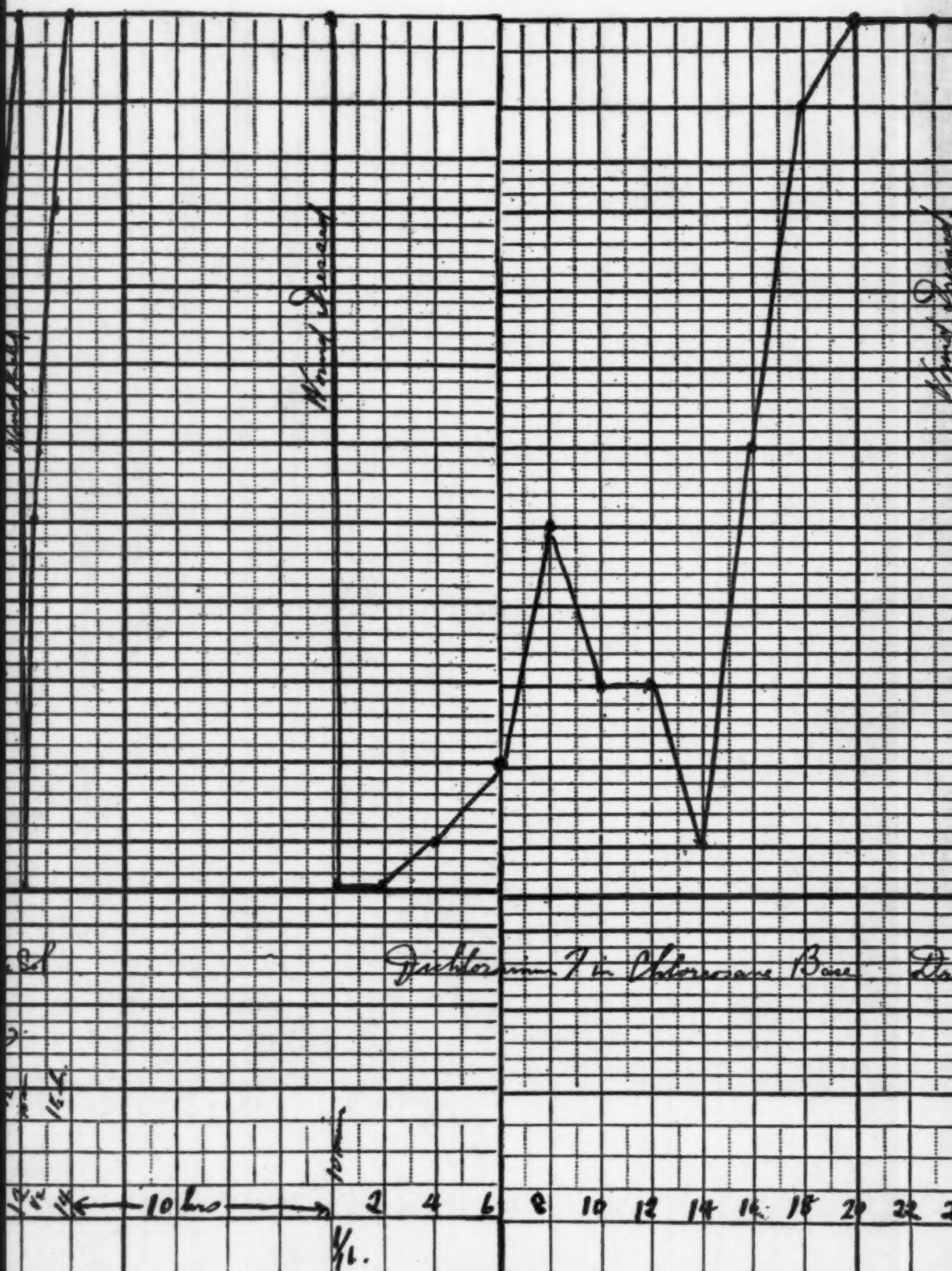


Second curve

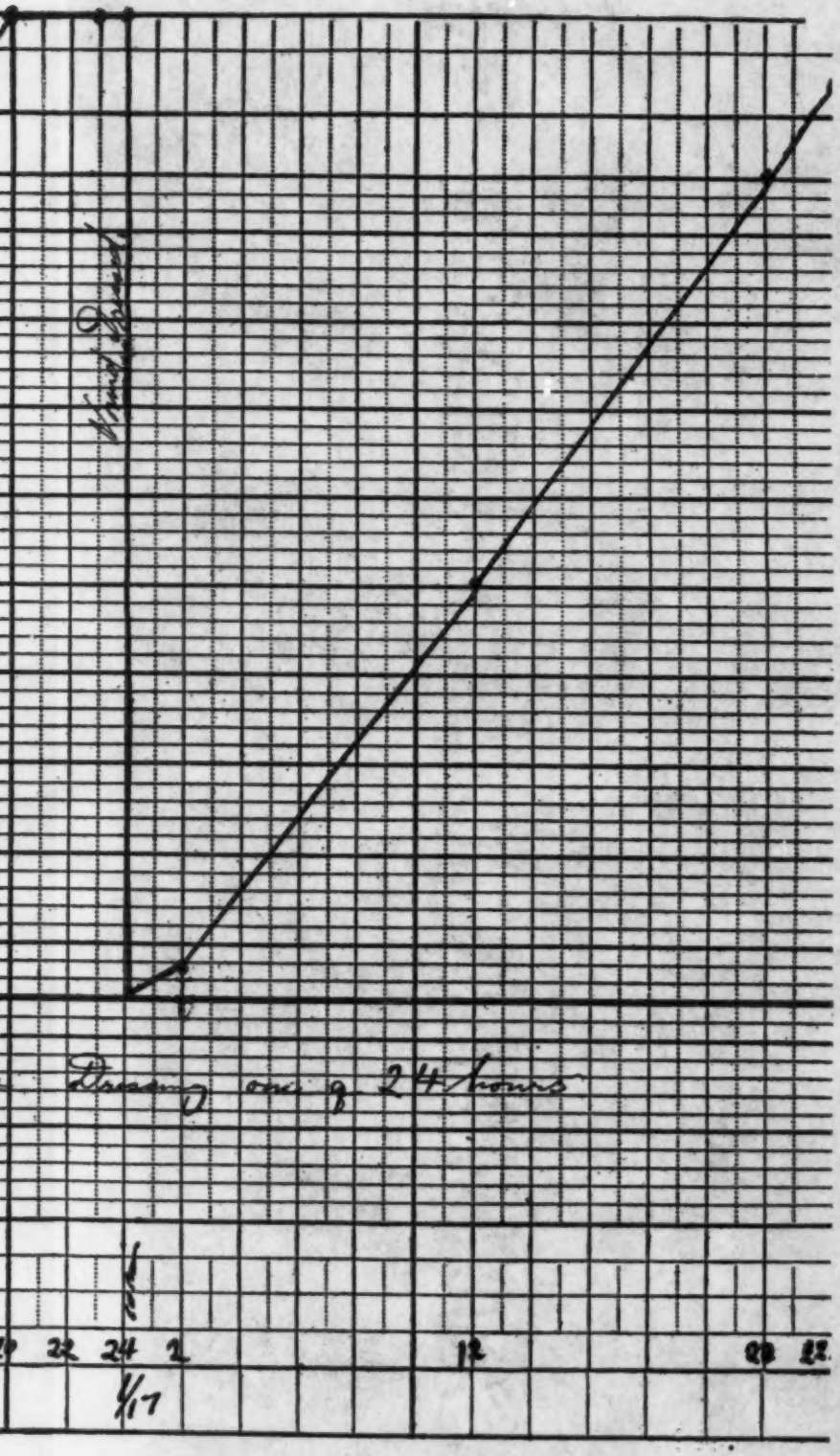
IG. 2

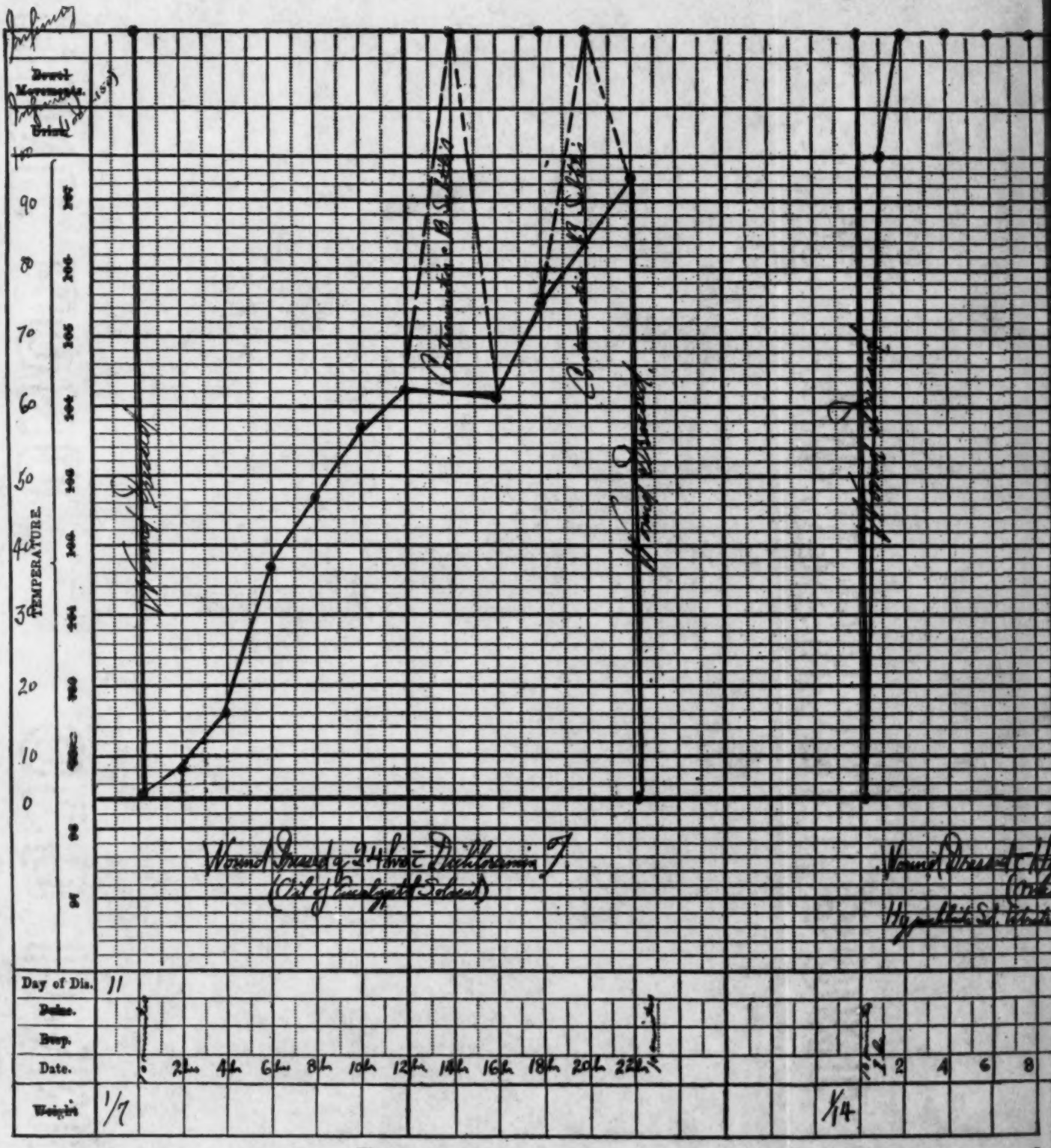


Third curve



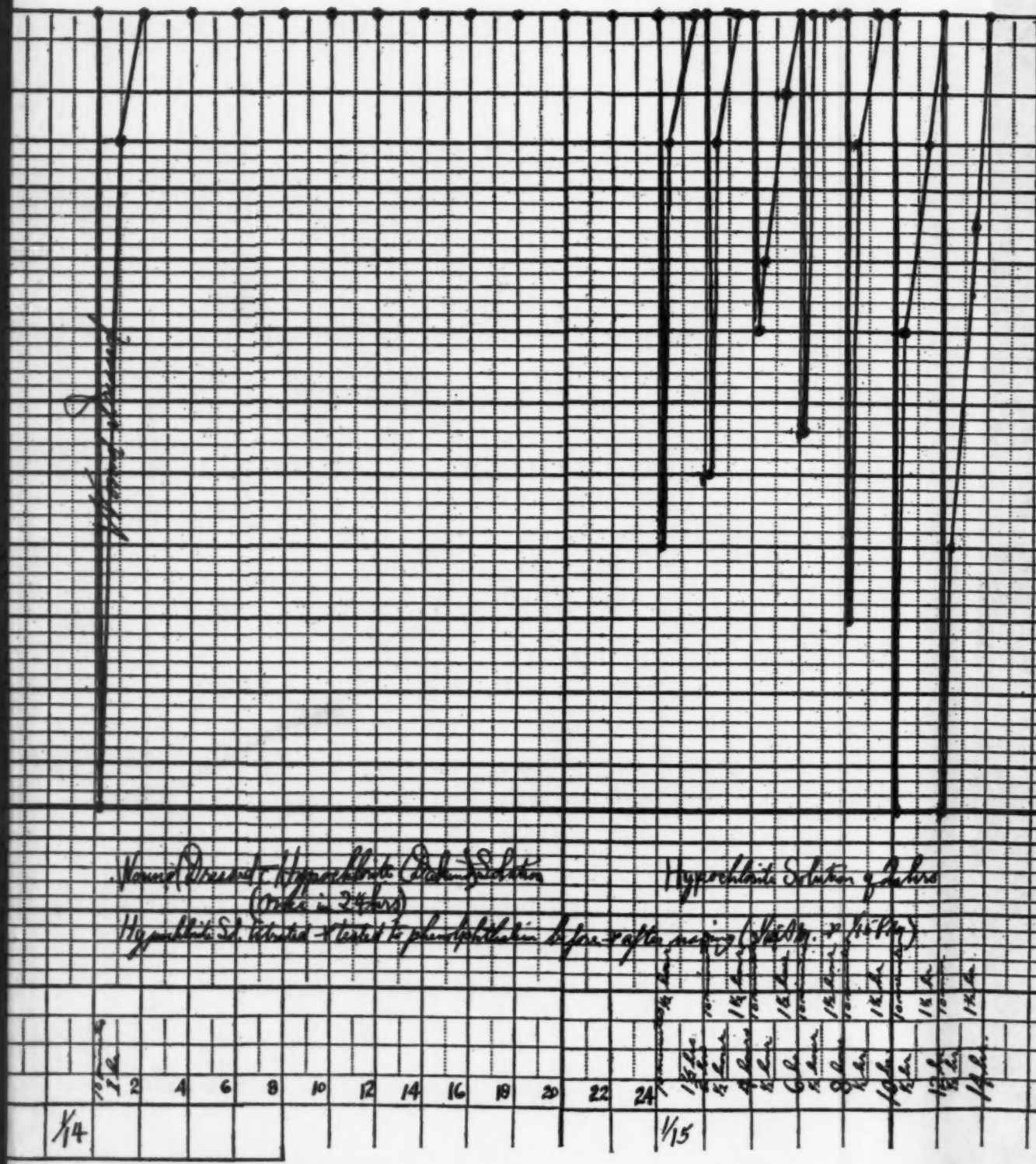
Third curve


Wind Speed
Drawing on a 24 hours
22
24
2
12
11/17

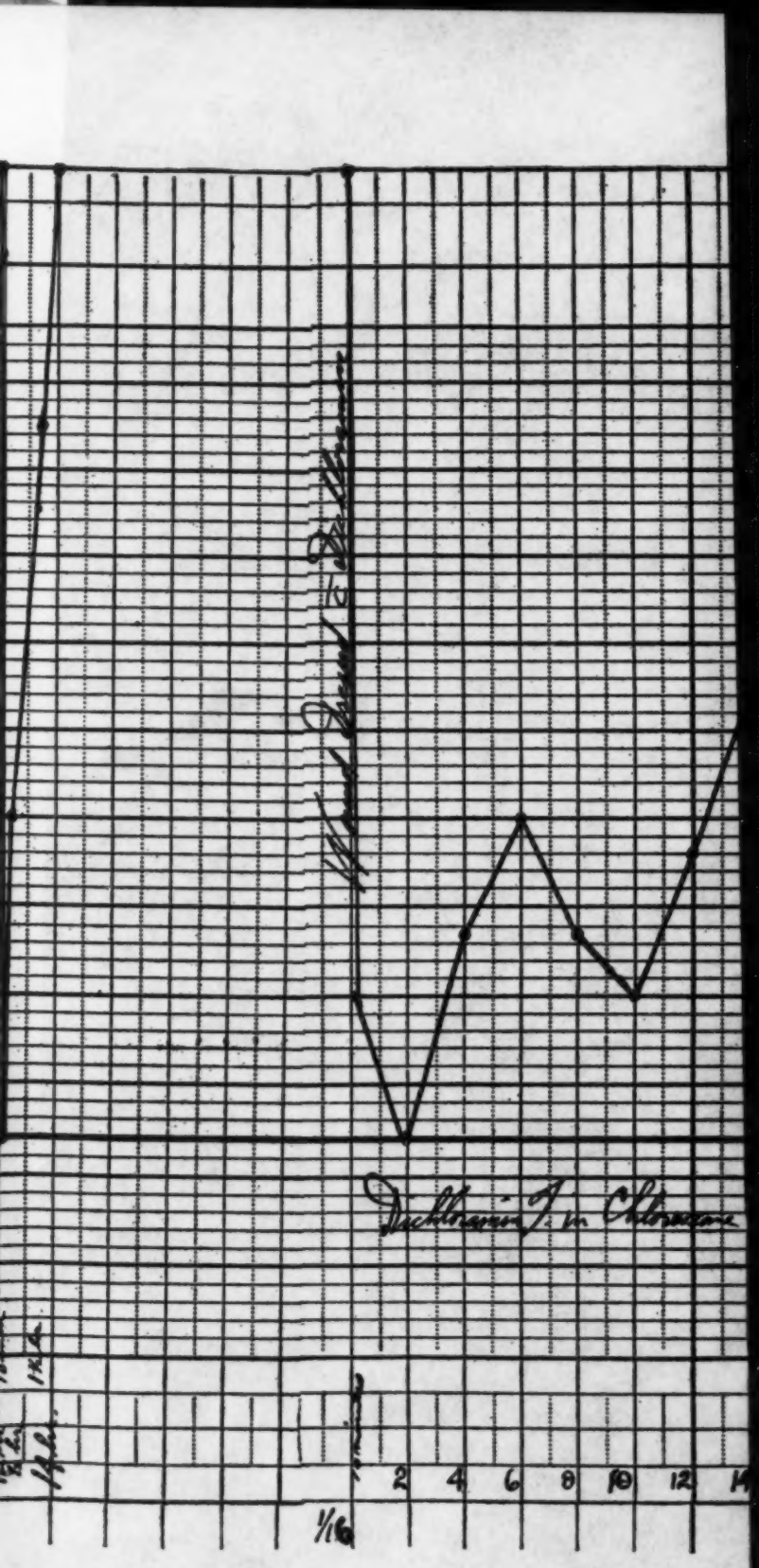

Bowel
Micturition
Urine
TEMPERATURE
Day of Dis.
Pulse.
Resp.
Date.
Weight

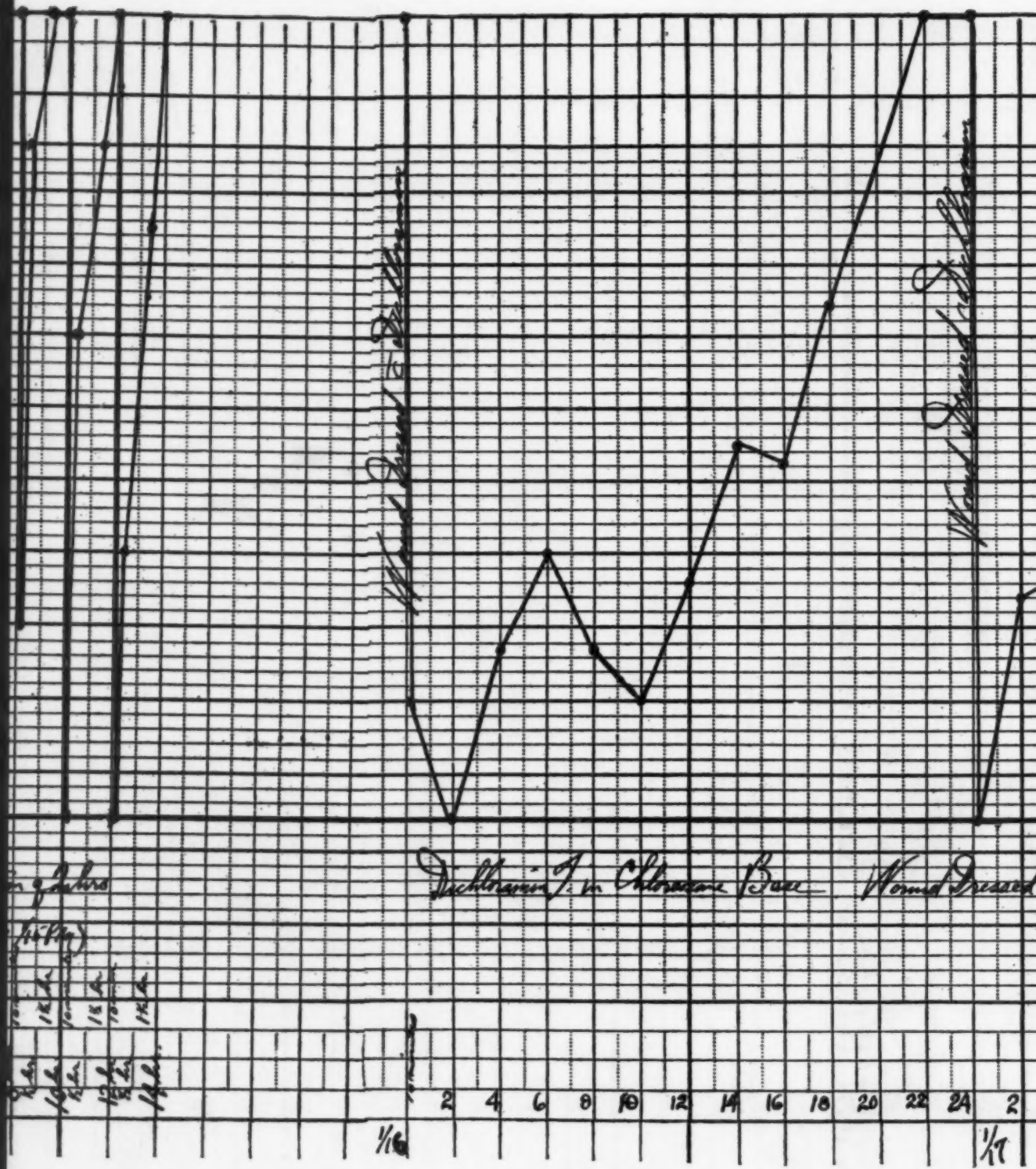
First curve

FIG. 3

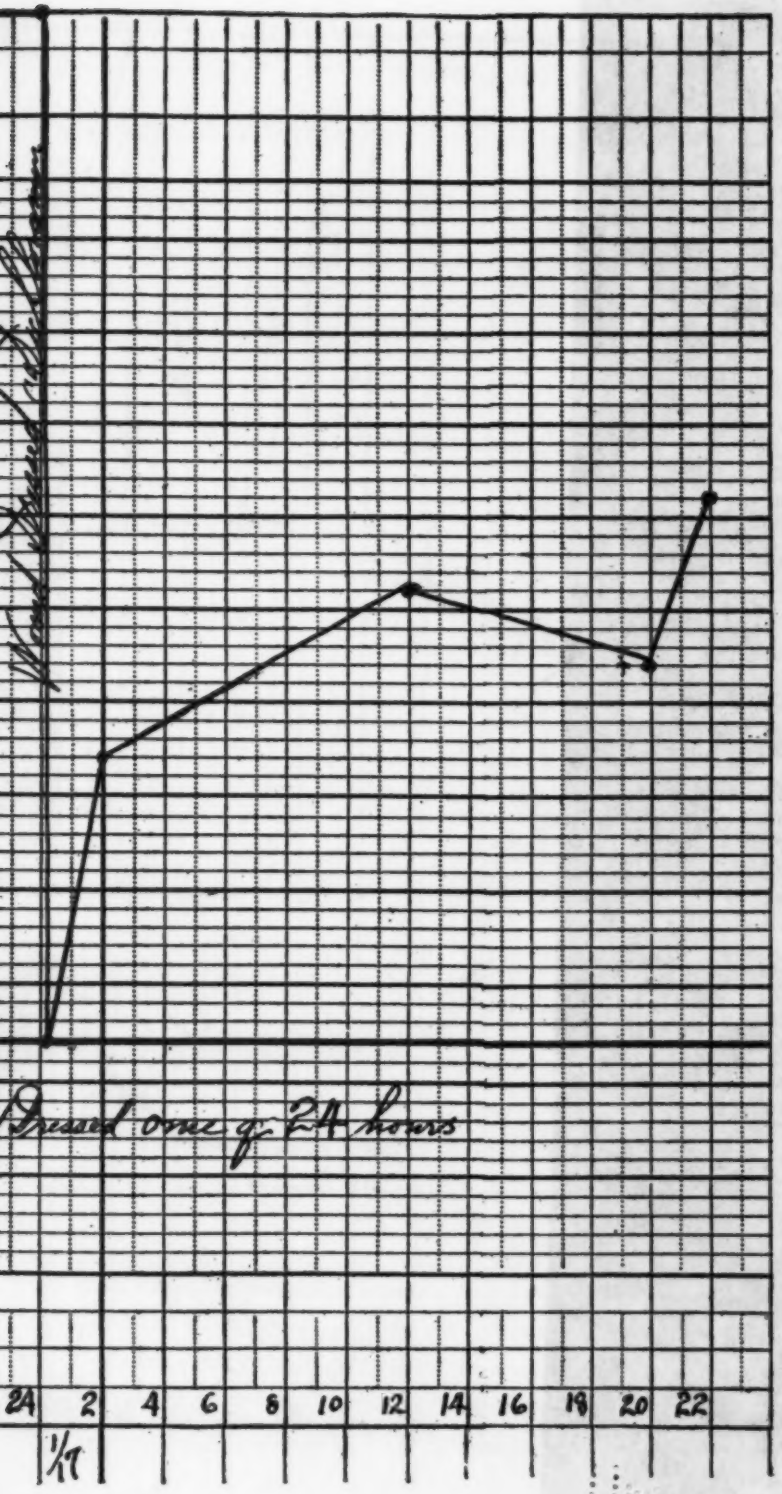


Second curve


Dichloramin-T in Chloramin
2
4
6
8
10
12
1/16



Third c



Third curve

December 27, 1917: The soft tissues of the leg were incised, the medullary cavity exposed for a length of 1½ inches. (A culture from the infected medulla showed staphylococci.) A moderate amount of pus and infected medulla was removed but no sequestrum found. The wound was then packed with gauze in dichloramine-T (5 per cent. in oil of eucalyptol). No sutures were inserted. The packing was removed at the end of twenty-four hours, and until the eleventh day the wound was dressed daily with dichloramine-T.

The microbe (smear) chart showed practically a straight line above infinity from the time of operation until the eleventh day. That day, before dressing, a culture was taken as described above. The wound was then dressed with dichloramine-T in oil of eucalyptol. Ten minutes later another culture was taken. Thereafter, for twenty-two hours, a culture was taken every two hours. The wound was dressed again. Ten minutes after dressing, another culture was taken. The results are shown on the first curve of Fig. 2.

From the twelfth to the eighteenth day the wound was dressed only with clean dry dressings. This time was allowed for the culture to again reach infinity. No antiseptics were used. Cultures were taken at irregular intervals.

On the eighteenth day, the plates having been at infinity for three days, the two-hour cultures were started again. This time hypochlorite solution was used. Cultures being taken ten minutes after dressing, one hour after dressing and then every two hours. The results are shown on the second curve of Fig. 2.

On the nineteenth day hypochlorite solution was used again. The wound was treated every two hours for twelve hours (hypochlorite solution being instilled after the Carrell method). Cultures were taken before dressing, ten minutes later, one-half hour after dressing, one and a half hours and two hours after dressing each time. (The hypochlorite solution (Dakin's solution) was titrated and tested with phenolphthalein before and after using).

On the twentieth day, the wound was cultured before dressing, then dichloramine-T in the chlorcosane solvent was applied. Ten minutes later and then every two hours cultures were taken.

On the twenty-first day dichloramine-T in chlorcosane again was used, the wound cultured ten minutes later, two hours later, twelve hours, twenty and twenty-two hours after dressing.

The results were recorded graphically on the ordinary temperature charts used in the hospital.

The other case, the results of which are shown in Fig. 3, was an American, forty-nine years old, a plumber by occupation, admitted January 3, 1918, with diagnosis of abscess of the right leg. The patient had had a chancre twenty years ago, but Wassermann reaction in blood taken while in the hospital was negative. X-ray reported. No evidence of bone change.

January 4: The wound had the appearance of a small carbuncle, was excised under ether, and the wound was packed with gauze saturated with dichloramine-T 5 per cent. in oil of eucalyptol.

Day after operation: Packing was removed and for the next two days the wound was dressed every twenty-four hours with dichloramine-T 5 per cent. in oil of eucalyptol.

Third day after operation: Cultures were started, as on the other case, and carried through in a parallel series and results charted.

In the first series, using the dichloramine-T in oil of eucalyptol once in twenty-four hours; following the initial drop there is a slow gradual rise in the curve, showing, we believe, a continual activity of the germicidal properties of the antiseptic lasting 16–14 and 18 and 20 hours, respectively, in the three cases.

Then with hypochlorite solution, there is again the initial drop followed this time by an immediate rise to infinity, in one case within an hour, in the other, two hours, showing the admittedly short time the antiseptic is active.

Using the hypochlorite solution every two hours, there is each time the initial drop, but each time before the following two hours are up, there is the rebound back to infinity; and after six instillations of the hypochlorite solution, twelve hours' treatment, the bacterial count is still above infinity, as against the comparatively low count of 100 and 62 in the same cases twelve hours after a single treatment with dichloramine-T.

In the last two charts, using again dichloramine-T, this time in the chlorcosane solvent, we have the initial drop followed by the gradual rise in the count, showing a germicidal activity lasting throughout the full twenty-two hours.

We feel that through this method some idea can be obtained of the comparative strength of antiseptics and the length of time during which they are active when applied to human tissues in the presence of infection.

TREATMENT OF GUNSHOT FRACTURES OF THE MANDIBLE*

By John B. Roberts, M.D.

Professor of Surgery, University of Pennsylvania, Graduate School of Medicine

Gunshot wounds of the lower jaw furnish very variable and many complicated fractures of that piece of the human skeleton. Blows received from slowly moving heavy projectiles may cause breaks practically indistinguishable from those seen in civil practice. Small rapidly moving bullets may simply bore a hole through one or both sides of the mandible, traversing the enveloping soft tissues with little damage. Large pieces of the body or either ramus of the mandible may be carried away or the fragments driven into the mouth, pharynx, or the soft structures of the face.

In addition to the comparatively inconsequential injuries, multiple and comminuted fractures occur from pieces of shell casing and from shrapnel; from secondary projectiles thrown into the face, and from blows with rifle butt, sword or bayonet. This discussion might be called a consideration of war, instead of gunshot, fractures of the mandible.

The shape, situation and function of the lower jaw and its relation to other facial structures lend to the vulnerating missile an extraordinary opportunity for serious complicating lesions. Much of the difficulty found by the surgeon in his attempt to restore the patient to his former military efficiency comes from the complications arising from sepsis. This danger is common to all war wounds and needs no special consideration. The removal of projectile and contaminating foreign substances, the prevention of infection by early aseptic excision of damaged tissues, the use of chemical antiseptics and the evacuation of cavities containing albuminous fluid liable to putrefaction should differ to but a moderate degree from the same activities in other regions. It may be said, however, that in the face an abundant vascularity, a free anastomosis of blood-vessels and the consequent unusual resistance to microbic attack permit greater retention, at the hands of the surgeon, of splinters of bone and of partially devitalized soft tissues than is wise in the limbs or trunk. The difficulty of maintaining a dry wound after reduction and fixation of an open or an infected fracture adds to the possibility of subsequent suppurative inflammation and septic necrosis. Establishment of free drainage by incision below the mandible, with introduction of tubes, so that gravity may aid in the escape of infected discharges, will do much to obviate the evil of saliva, food and nasal mucus reaching the wounded surfaces. Giving water and liquid food through a funnel and soft rubber tube, for a week or ten days, may be very valuable as a preventive measure in fractures accompanied by wounds likely to assume septic complications.

* Read before the Philadelphia Academy of Surgery, April 4, 1918.

When one recalls the shape and function of the mandible, the real reason for its frequent malformation after union of a fracture is obvious. The bone reminds one of a crude horseshoe, with a high caulk at each end, applied to the skull upside down. Each caulk terminates in two projections. The posterior projection ends in a cylindrical knob for articulation with the temporal bone of the cranium, the anterior is flattened for the grasp of the tendinous insertion of the temporal muscle. This rude model of a horseshoe is furnished with sixteen sockets, on the same edge as that from which the caulks arise, for the roots of the lower teeth. When man opens his mouth for eating, drinking, or speaking, the mandible moves downward from the cranium and face as a hinged bottom drops from a box. The axis of motion is a transverse line drawn through the two rami a little above and a little behind the third lower molars. In addition to the open and shut movement of the jaws, there occur, during mastication, crushing and grinding motions of the molar teeth, caused by the action of the masseter and pterygoid muscles.

It is fortunate for patients who sustain fracture of the lower jaw (mandible) that the two upper jaw bones (maxillæ) above furnish an immovable anvil against which the teeth of the mandible strike in chewing food. This anvil-like mass of bone and teeth may be utilized by the surgeon as a splint to support and steady the broken lower jaw after its fragments have been so replaced as to reconstruct the dental arch. This may be done with muslin bands furnished with hooks glued to each jaw and then laced.

It is an axiom that the broken mandible should have the contour of its body or arch readjusted in a manner to reproduce the occlusion of upper and lower teeth existing prior to the occurrence of fracture. The surgeon thus has his patient's upper jaw for a standard, by which to assemble the various fragments of the mandible found in a gunshot or a comminuted fracture. This happy condition may be unattainable, because many patients have previously lost teeth in one or both jaws, or some teeth have been carried away by the gunshot force which produced the fracture awaiting reduction.

The usual fractures occurring in the body of the mandible are not difficult to reduce and keep reduced, if both jaws have intact teeth. The difficulty of reduction is usually not great in other circumstances, unless there has been great loss of teeth or marked ablation of bone by the trauma of the projectile. One readily obtains a proper occlusion of the teeth, and then holds the mandible against the maxillæ by means of an external bandage, chin-strap, or splint. In comminuted injuries the reduction is not apt to be easy; and its maintenance may be difficult. The absence of teeth, even if only a few have been lost, prevents very often the successful employ of the upper jaw as a supporting splint. The operator must then devise a method of fixing firmly the fragments in apposition by means of interdental or intermaxillary splints or by the adaptation of some mechanical connection or bridge between the major fragments.

The general surgeon may undertake the treatment of severe fracture of the body of the mandible with some hesitation, because he realizes his unfamiliarity with dental manipulations within the mouth. Much of this is due to a want of consideration of the relations of the teeth to the fracture and a neglect of a study of the mechanical and anatomical needs of the injury. A dental surgeon may have, it is true, a manual dexterity and an experience which give him an unusual facility in treating mandibular fractures; but a surgeon without a sufficient degree of alertness and deftness to learn the few needed manipulations must be a sorry surgeon also in other technical procedures. The principles by which fixation of mandibular fragments is to be obtained can in all most exceptional cases readily be learned by a painstaking and conscientious operator. It is well for us to take steps to acquire such knowledge.

Reduction of the fracture by pressure of the fingers on the teeth is generally easy, though comminuted fragments or displaced teeth may cause interlocking and require removal before correct apposition is obtained. Teeth which are simply loosened should not be taken out unless they impede reduction or are situated within the line of fracture; then it is wise to extract them. The normal relation of the upper and lower teeth in most mouths brings the upper incisors in front of the lower when the mouth is closed.

In usual fractures of civil life, little tendency to displacement is shown after the lapse of ten days of treatment. Retentive dressings may usually be removed about two weeks from the time of readjustment of the dental arch. The patient may then be given an opportunity to cautiously chew soft food and to demonstrate whether the fragments have been so adjusted as to give the best use of the teeth for mastication. Consolidation at that time will not be so complete as to preclude slight changes at the hands of the surgeon for a better adjustment of fragments.

After the surgeon has brought the fragments into apposition in uncomplicated fractures, the upper and lower teeth should be kept in contact by closing the mouth and then holding the mandible firmly against the upper jaw by a figure-of-eight bandage of occiput and chin, or by some similar appliance, to prevent the patient opening his mouth. This is not a difficult matter if all or nearly all the teeth are present in both jaws.

The mouth should be cleansed with disinfectant washes frequently, and feeding carried out by introducing liquids through the crevices between the teeth or through a tube passed between the cheek and teeth into the space behind the last lower molar. The hair and beard of men should be closely cut before external bandages are applied, in order to prevent slipping of the bandage and to add to the comfort of the patient. When a simple bandage will not give sufficient firmness or when its lateral or backward pressure causes over-riding of fragments, a molded splint should be applied to the outside of the skin, to constitute a hollow cap fitting the front and lower surfaces of the mandibular region. The splint should extend on each

side nearly as far back as the angle of the jaw. It may need a crescentic portion of its posterior edge cut away in order to avoid pressure on the throat above the larynx. The splint is to be padded, unless molded from gypsum and gauze, vulcanized rubber, or modelling compound. Before applying the bandage, the chin splint may be steadied by carrying a strip of rubber adhesive plaster over the splint and bringing the ends high up on the cheeks. Although most fractures in the dental arch communicate with the mouth by tears of the closely adherent gums, the fracture does not usually become infected. This rule does not hold good, however, if the fracture is a comminuted one or the mouth allowed to continue fetid during the treatment.

If the tendency to displacement is persistent, wiring the fragments together, or fixing one or more teeth of the mandible against those of the upper jaw by wires carried across from the teeth of the mandible to the teeth of the maxillæ may be a valuable expedient. Provision must be made for immediate release in the event of vomiting from anæsthesia or seasickness. Sometimes fixation by an intraoral or dental splint becomes necessary. Wiring the fragments in position may be done by passing a strong silver thread around several teeth on each side of the fracture and twisting the ends tightly with pliers. Rebellious fractures may require the ends of the bone to be drilled and wire sutures passed through the drill openings. This is most apt to be needed when the jaw is toothless or greatly atrophied near the point of fracture.

Dental splints are appliances worn inside the mouth and so fitted to the teeth and alveolus of the mandible that motion at the seat of fracture is prevented. A plastic impression of the teeth and alveolus is taken while the fragments are held in position; and from this a splint to fit the irregular outlines is made of rigid material. In making an intermaxillary splint, a similar impression is taken also of the maxillæ above. By means of impressions thus made in plaster-of-Paris, a splint of metal or vulcanized rubber is constructed with indentations into which the properly adjusted teeth properly fit. By applying such a dental or intermaxillary splint to the teeth, the bone is held continually in contact with it and mobility at the seat of fracture rendered impossible. This immobility is due to the crowns of the teeth being buried in the indentations on the surface of the splint. The simple dental splint fitting the teeth of the mandible alone and fastened to the alveolus may be sufficient. Instead of a dental splint, it may at times be better to construct a splint with indentations to hold the teeth of the upper jaw on one surface and the teeth of the lower jaw on the other surface. This is the intermaxillary splint. If a splint is made for the mandible alone it is fastened to the jaw usually by rods coming from it at the corners of the mouth and then attached to a splint beneath the chin. This device is probably not as convenient and satisfactory for preventing lateral movements as the intermaxillary splint steadied by close contact with the upper as well as the lower teeth.

A temporary splint may be made by softening a gutta-percha strip in hot water, molding it to the crowns of the lower teeth so as to overlap the adjacent gum, and hardening it with cold water. Such a splint may be held in position by wires carried by means of needles through the muscles in the floor of the mouth, and out through the skin of the chin, so that they may be twisted under the mandible over small rolls of plaster or pieces of cork. In subjects who have lost all or nearly all their teeth, interdental splints molded to the atrophied gums present about the only efficient means of maintaining immobility. In all forms of splints greater immobility will, as a rule, be obtained by bandaging the jaws together. If desirable, gutta-percha wedges may be placed between the jaws on each side of the mouth, in order to have a space in the middle for introduction of food. A crude form of intermaxillary splint may be made of cork cut to fit the teeth of the two jaws. An impression tray, such as is used by dentists in taking impressions for dentures, may be utilized as an emergency splint by putting softened modelling compound in its grooved surface and attaching wires to be thrust through soft parts and twisted under the mandible outside of the face.

Union of ordinary fracture of the mandible takes place in about five weeks. In many cases apparently likely to give bad position there is ultimately quite a good result, provided that sepsis does not occur and a fairly good apposition of fragments is maintained during the early stages. This statement, however, is subject to many qualifications, the most important of which is that a general surgeon without technical knowledge of the value of dental skill may obtain much poorer results alone than if he has the advice of an able dentist. The tray idea may be utilized to form an intermaxillary splint, if the surgeon will fasten two trays together by means of a posterior hinge. Softened modelling compound placed in the gutter of each tray will allow impressions to be taken. When the compound has hardened the trays and their contents will be efficient as an emergency splint.

When there is a considerable loss of the bone at or near the symphysis, the two fragments will probably be drawn together by the muscles displacing the broken bone; this later will be increased by cicatricial contraction. Thus is given a narrow arch; and sometimes the contraction makes a V-shaped lower jaw. Such a deformity makes it impossible for the teeth in the mandible to have proper occlusion with those of the maxillæ. The patient, therefore, is unable to properly masticate food. When the fracture is in the lateral portion of the body, the larger fragment is usually drawn toward the smaller which is situated on the fractured side. This causes deviation of the chin to the broken side.

The normal occlusion of the teeth should be re-established in gunshot fractures as soon as possible, even before there is any general suturing of stripped-off soft tissues, if these are greatly lacerated. Unless this is accomplished, the fracture displacement will probably become permanent and reconstruction of the contour of the face very difficult to effect. When

a portion of the bone is deficient as the result of fracture, the immediate treatment should be conducted in very much the same way as that which is necessary subsequent to excision of the mandible for tumor or necrosis. The operative or accidental loss of a portion of the body of the bone requires that displacement should be prevented early by holding at once the pieces in normal position. This may be done by placing between the ends some plastic material which becomes hardened after its adaptation. The ends of the bone may be held in position also by heavy wires bridging the gap and attached to the teeth on opposite sides. The rigid wire used in this manner, when there are no teeth for its attachment, may be inserted in the inferior mandibular canal or passed through drill holes made through the sawed off ends of the bone.

Several forms of splint have been devised for this purpose. Bands or caps may be fitted or cemented to the teeth and a metal arch or a vulcanite substitute for the bone be introduced between the fragments. After a few weeks wearing of the apparatus, the displacing tendency may, perhaps, be overcome. Vulcanite prosthetic parts of the bone may be used to support plastic flaps, and vulcanite plugs may be used to push the collapsed cheeks into proper position, so as to remedy traumatic deformity. Temporary fixation is, therefore, to be always sought in war surgery as early as possible. A dental surgeon may be needed to properly make and apply the special forms of intraoral splint or apparatus needed to maintain adjustment of mandibular fragments in civil as well as military surgery. Torn-off soft tissues may sometimes be held against the underlying bones of the face with tacks or small staples driven into the bone. The bones may be kept coapted at the seat of fracture with screws or fracture plates of steel or aluminum. This method is usually inferior to that by intraoral splints.

Most gunshot fractures of the mandible are open and, therefore, liable to become contaminated, and later infected. The treatment of the wounds has been touched upon already. Large areas of skin and muscle may be detached from the bones of the face in gunshot wounds. The raw surfaces should be cleansed and well painted with tincture of iodine, or dichloramine-T, or other antiseptic, and vulnerating missiles and foreign bodies thoroughly removed as soon as possible after injury. These fractures should be reduced immediately and the fragments fixed. Even a temporary fixation of fractures is of distinct value as a preliminary to reconstruction of the facial outlines.

If the mandible alone is broken, the upper jaw may be used as a support or splint. To do this, place a mass of softened modelling compound between the upper and lower teeth and drive the upper jaw and mandible into it in the position of occlusion. The composition is then allowed to harden in position. This gives a very fair splinting of the broken lower bone. The chin may be supported with a cap of pasteboard, metal, or modelling compound held in position by a figure-of-eight bandage of occiput and chin. Fastening the upper and lower jaws together by wire ligatures around oppos-

ing teeth of the bones may also be serviceable until a better form of apparatus for steadying the broken mandible can be obtained. Some of these methods may in fact be employed as a permanent means. They may also be used at times in steadying fractures of the upper jaw, though in these there is usually less displacement than in those of the more movable mandible.

The soft parts may be brought together over the broken bone after the fracture has been reduced. They should not be sutured so closely as to interfere with drainage, if there is a probability of infection becoming marked. Care should also be taken not to stitch the muscles and skin in so tight a manner as to tend to reproduce deformity at the seat of break. When large flaps of tissue have been torn from the bones, stitches occasionally need relief of strain. This may be accomplished by molding plates of vulcanite to the forehead and cheeks, fixing these by straps around the head and connecting with them by jointed steel springs of heavy wire. To the ends of these springs are attached truss pads to press and hold like fingers the detached soft parts into normal position. Tacks or staples may be employed to hold such accidental flaps against the bone, if sutures are not available.

Drainage will be particularly needed in damaged tissues of the lower facial region and chin. This should be provided for in some cases of fracture of the lower jaw by incision below the inferior margin of its body. Practically all fractures of importance in the alveolus and body are contaminated through the wounded gum with saliva and food products. Many such fractures will probably heal more promptly if, at the time of the original dressing or shortly afterwards, an incision is made below the inferior margin and drainage established. The gum is torn at the time of injury because it is so closely adherent to the bone. This adherence, however, is a protection against spreading of infection.

There occurs at times great swelling from laceration of the tongue or infection of that organ and the other tissues within the mouth. This complication may require that the breathing of the patient be provided for by laryngotomy. Possibly a tracheotomy some distance below the larynx even may be demanded. If the attachment of the tongue to the symphysis of the mandible is severed by reason of operation or the complicated character of the fracture, the patient may become asphyxiated by the tongue falling backward and closing the opening of the glottis by pushing the epiglottis downward and backward. To avoid this catastrophe, the swollen tongue may need multiple incision to lessen its bulk. It sometimes is wise especially after anæsthesia to put a long string through the end of the tongue, knot it at the ends and leave a hemostat attached to it. This instrument by its weight holds the tongue forward, and can readily be seized by the patient himself or nurse to re-establish breathing, should the tongue fall dangerously backward. This string with the attached hemostat may be removed at the end of twenty-four hours.

Major V. P. Blair gives a valuable series of suggestions on the treatment

of mandibular fractures due to gunshot and shrapnel injuries. These may be epitomized as follows:

(1) *Fractures of the body of the mandible in front of the last existing tooth with no loss of bony substance.* This type may occur from concussion without the projectile striking the jaw. Fixation may be obtained by the usual methods of civil practice.

Hullihan continuous dental splint and Gilmer's vulcanite lingual band splint wired to teeth, shown in this article, are satisfactory in such cases.

(2) *Fractures of the body of the mandible in front of the last existing tooth with considerable displacement or considerable loss of substance and with few teeth remaining.* The majority of gunshot fractures, according to Blair, belong in this class. Fixation is to be secured in the two usual varieties as follows:

(*a*) With loss of substance at the symphysis the tendency is for the fragments to be drawn together in front with the occlusal surfaces of the teeth facing each other.

(*b*) If the loss of substance is in the lateral portion of the bone, the fragment on the sound side is drawn over toward the affected side.

In both instances, the fragments, which are separated by a gap due to the avulsed bone, are best held apart and fixed in normal relation to the upper teeth by the metal jacket and wire splint described by Hayes. This may be made in one solid piece; or it may be applied to the bone in sections, which are subsequently fastened together.

(*c*) When there is a tendency for the lower jaw to swing over to one side, on account of the loss of substance, the outer surface of the splint on the opposite side may be furnished with a metal flange to engage the teeth of the upper jaw. This acts as an inclined plane to throw the teeth into proper occlusion when the jaws are closed.

(3) *Fractures of the mandible behind the last existing tooth.*

These fractures include those of the body of the bone, the ramus, and condyle.

(*a*) If no tendency to displacement is present and no loss of substance has occurred the simplest method of treatment is fixation of the lower jaw to the upper with ligature wires directly applied to the teeth, or by the employment of Gilmer's posterior or lingual arch already shown in a previous figure. Always provide for prompt release of the jaws to permit vomiting if the wounded man is liable to seasickness or vomiting from any cause.

(*b*) Fractures of the angle and ascending ramus with loss of bone without displacement may be treated by wiring without splint (see Fig. 1).

(*c*) If the ramus is displaced either forward or laterally, the anterior fragment may be fixed by wiring the teeth to those of the upper jaw and the ramus steadied by means of an intraoral plastic splint of modelling composition. This is molded within the mouth. The ramus is drawn back with a hook introduced through the cheek or a lion-jaw forceps holding it through the skin. While it is thus supported the modelling compound

FIG. 1.—Gilmer's method of fixation by holding mandible against maxillæ with wires around necks of the teeth. (Blair from Gilmer's Oral Surgery.)

FIG. 2.—Impression tray to be used as Kingsley splint temporarily by filling it with softened modeling composition. (From Blair's Injuries of Jaws.)

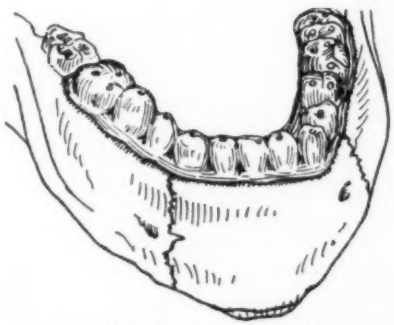


FIG. 3.—Hullihan continuous dental splint. (Blair after Angle.)

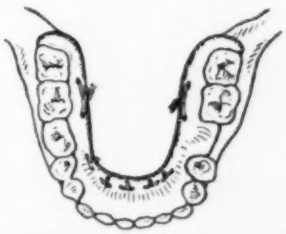


FIG. 4.—Gilmer posterior band splint in place. (Blair.)

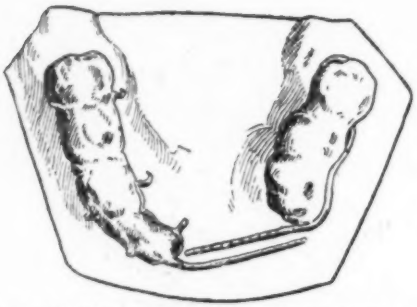


FIG. 5.—Model of a sectioned metal jacket and wire splint; the two halves to be lashed together with fine wire. (Blair after Hayes.)

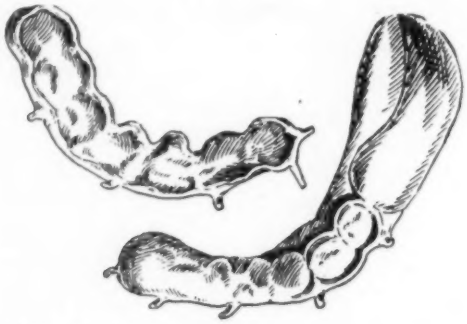


FIG. 6a.—Swaged metal jacket splint with hooks for ligature wire. (Blair after Davenport.)

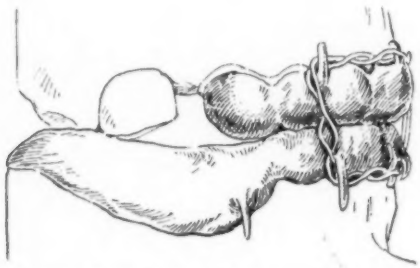


FIG. 6b.—Model showing swaged metal jacket splint as applied to teeth and wired to fix jaws. (Blair after Davenport.)

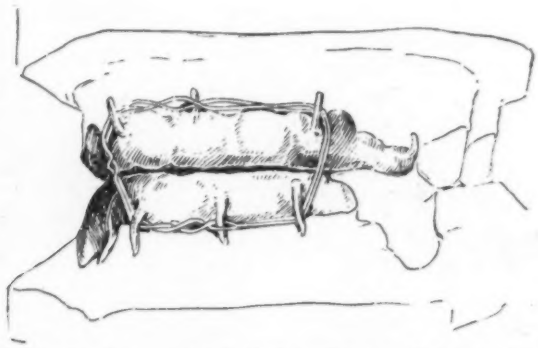
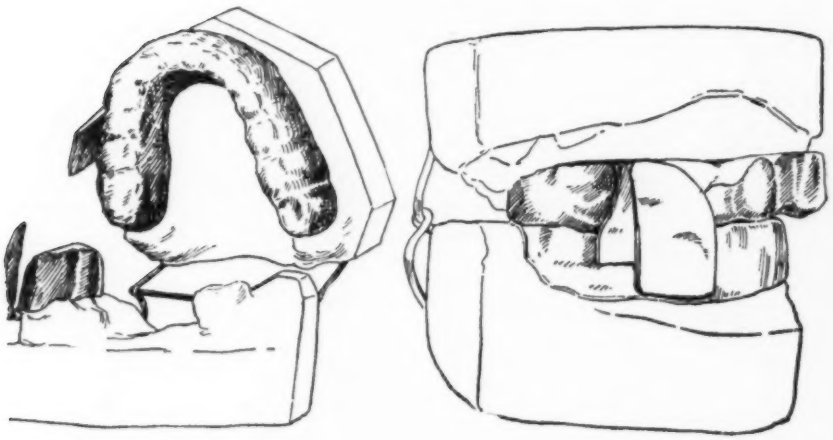


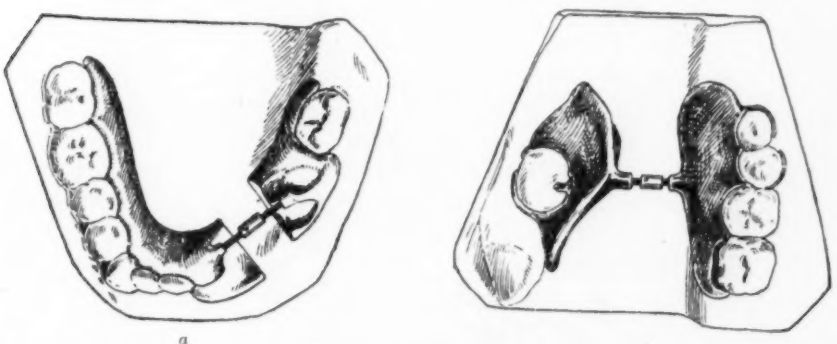
FIG. 6c.—Model showing swaged metal jacket splint as applied to fix jaws together. (Blair after Davenport.)

FIG. 7.—Lower bar and saddle splint. (Blair after Herpin.)



a *b*

FIG. 8.—Metal jacket splints with inclined planes to throw teeth into proper occlusion when mouth is closed by bringing jaws together. (Blair after Hayes.)



a *b*

FIG. 9.—Models of sectional vulcanite splints with jack screws for slow separation of fragments of fractured mandible drawn together by muscular traction.

is introduced, applied to the maxilla above and the ramus of the mandible and allowed to harden between the ramus itself and the last molars of the upper jaw, but continuing downward behind the mandibular molars. Remember the danger of a locked mouth in the event of vomiting during transportation or travel by sea.

(*d*) If no teeth are available for wiring the jaws against each other, intermaxillary fixation with ligature wire may be applied. This is done by drilling holes through the mandible at the level of the roots of the teeth about three-quarters of an inch distant from the fracture line on each side. Through these openings strong wire is carried and twisted so as to hold the fragments in coaptation. Other holes are drilled in the upper and lower jaws in the incisor region, or in other satisfactory sites, and wires for approximation and fixation are carried through both jaw bones so as to give firm contact of mandible to maxillæ. The fracture is then reduced and all the wires twisted to maintain the corrected position at the seat of fracture. Early release may be afforded by teaching the patient how to cut or untwist the ends of the wires in case of nausea or vomiting. Long ends to the wires or the habitual presence of strong scissors may thus save life from threatened suffocation with vomitus.

(*e*) Upper and lower swaged metal jackets may be found serviceable in the fractures under discussion. Sometimes the tendency to displacement in a lateral direction may be overcome by attaching to the splints hooks to which intermaxillary rubber bands may be fastened. If it is thought necessary to hold the jaw in fixation with the mouth open, in order to prevent forward displacement of the ramus, the Herpin splint seems available and likely to be useful.

Gunshot fractures of the mandible are so essentially open fractures in most cases that osteomyelitis and other septic complications are common. Necrosis may thus impede union and cause permanent non-union with atrophy of the ends of the fragments. A definitely false joint may result at the point of fracture. Violent primary hemorrhage may occur from the missile injuring the lingual, facial, or one of the carotid arteries. Secondary bleeding may threaten the life of the patient. Septic œdema of the tongue, throat or glottis may give origin to dangerous dyspnœa. Unintelligent treatment or the character of the osseous injury may cause union to occur with great deformity of the mandible, malocclusion of the teeth or facial disfigurement from scar contraction. These sequels require active operative treatment on general surgical principles. Bone transfer by flap from clavicle or grafting from rib or tibia may enable the surgeon to reconstruct the mandibular arch; or he may use a graft of costal cartilage for this purpose.

It is probable that about one-half inch of lost substance in time may be reproduced across the gap between the fragments of a broken mandible, if normal occlusion of the teeth is maintained by fixing the jaws together. Morestin prefers for grafting sections of the sixth, seventh, and eighth costal cartilages. These he shaves into proper shape with a knife, and accurately

fits them into the gap with their ends driven into the bone. He uses such grafts to reconstruct the angle and vertical ramus as well as the horizontal ramus. Although the cartilage may not be converted into bone and may not actually assume firm union with the ends of the fragments, the false joint is not, he says, of much disadvantage. Fixing of the jaws together is necessary in the after treatment.

Pont advocates the use of tibial bone grafts and insists upon absolute fixation of the mandible against the maxillæ after the grafting operation. This immobilization is maintained for several months. Instead of grafting, a bone transfer may be made by chiseling off a part of the sternal end of the clavicle, leaving the sterno-mastoid attachment as a muscular pedicle, or by turning up a flap from the chest and neck, including a plate of bone from the front of the clavicle.

Further experiences of these and other writers will probably modify methods in minor details.

OPERATIVE TREATMENT OF HERNIA*

A CONSIDERATION OF 8589 CASES OF HERNIA TREATED BY RADICAL OPERATION FROM 1891 TO 1918, WITH SPECIAL REFERENCE TO METHODS OF OPERATING AND END RESULTS

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AND

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OF New York

In order to study the merits of the surgical treatment of hernia it is essential to consider a large number of cases that have been operated upon. We have therefore collected all of the cases operated upon at the Hospital for Ruptured and Crippled since 1890 and the cases operated upon outside of that institution by Doctors Coley and Hoguet. The total number of cases under consideration is 8589. Of these, 6090 were operated upon at the Hospital for Ruptured and Crippled by Drs. Wm. T. Bull, William B. Coley, John B. Walker, Wm. A. Downes, C. G. Burdick, D. H. M. Gillespie and J. P. Hoguet. Of the remainder, 1966 were operated upon by Doctor Coley and Doctor Downes, and 595 by Doctor Hoguet in hospitals other than the Hospital for Ruptured and Crippled. By giving the details of this large number of cases we believe we can demonstrate the efficiency of certain operative methods of treatment in certain types of hernia, as in all these cases a certain very definite operative technic was closely followed by the operators mentioned above. As can be seen from the accompanying tables, all types of hernia are included in the series and the patients were operated on at all ages, so that in every way the series is very wide in its scope. Great efforts have been made to keep in touch with patients after operation. A large number report back at certain regular intervals and postal card inquiries are addressed to all at yearly intervals. We therefore think that we have traced the larger number of the recurrences that have occurred among our cases.

Lack of space will not permit any reference to the older methods of operation for the radical cure of inguinal hernia, which were largely abandoned with the advent and early adoption of Bassini's method in 1890 and the years immediately following.

Of the various methods brought out since 1890, the majority have been more or less modifications of the Bassini method, and the more they have departed from the underlying principles of Bassini's method, the less satisfactory have been the results. The Halsted operation originating almost simultaneously with, though independently of, the Bassini method, resembling it in the main features—the transplantation of the cord and suture of the internal oblique muscles to Poupart's ligament—while a great improve-

* Read in abstract before the American Surgical Association, June 8, 1918.

ment on the methods which preceded it, had certain disadvantages which did not attach to the Bassini method, and it soon gave place to the typical Bassini operation.

Among the other methods that came into vogue shortly after the Bassini method, and which proved so efficient that they are still regarded as methods of choice by many surgeons at the present time, may be mentioned the so-called Ferguson method (Chicago) and the Wyllis Andrews method. Both of these methods closely resemble Bassini's method in many respects, the Ferguson method being practically identical with the Bassini method, with the step of the transplantation of the cord omitted. In the Andrews method, not only the transplantation step is omitted, but a special method of applying the overlapping principle originally outlined by Championniere is made use of in closing the canal.

All of these methods embody the main principles of the Bassini operation —namely, the long external incision parallel with Poupart's ligament over the centre of the inguinal canal, with free splitting up of the aponeurosis of the external oblique. This latter important step for the first time made it possible to expose clearly the internal ring and permit complete removal of the sac at or beyond its neck, thereby obliterating any funicular process of peritoneum which might favor the early recurrence of the hernia. The second important principle of Bassini's operation is also included in these modifications: The suturing of the internal oblique, and sometimes the external, to Poupart's ligament. The transplantation step was believed to be an unnecessary part of the technic and of little value, and therefore omitted.

Good, even excellent, results were obtained by many surgeons who adopted these modifications of Bassini's method.

We think it might be wise to give a brief description of the exact technic of the different operations as performed by us.

Inguinal Hernia (*indirect*).—First, an incision 2½ to 3 inches long (or 3 to 3½ inches in adults) is made parallel with Poupart's ligament and about ½ inch above it, so that the lower end of the incision comes directly over the centre of the external ring.

Second, the aponeurosis is slit up a distance of 2½ to 3 inches in the direction of its fibres—in doing this it is important that the director should be withdrawn and the aponeurosis cut very carefully so as to avoid severing the ilioinguinal nerve which is frequently sacrificed at this step.

Third, the aponeurosis is dissected well back on the inner side towards the rectus muscle, giving a full exposure of the internal oblique muscle. On the outer side, the aponeurosis is dissected until Poupart's ligament is exposed to the pubic bone.

Fourth, the sac and cremaster muscle just over the canal and above the external ring are seized with a pair of thumb forceps and lifted up and the muscular fibres pushed aside by means of a pair of blunt-pointed curved scissors. The white tissues of the sac are thus quickly exposed and held by a

pair of artery clamps in the left hand, and with the thumb and fingers of the right hand the cremaster muscle is quickly and easily dissected from the sac and cord.

Fifth, the next step is to cut through the layer of infundibuliform fascia which surrounds the sac and cord in common, change the clamp so that it grasps the exposed sac over its anterior margin, then with the thumb and forefinger of the right hand and a piece of gauze the cord is separated from the sac, until the sac occupies a position above the forefinger of the left hand and the cord below. The sac is then cautiously opened to determine whether it is empty or contains omentum or bowel. If empty the anterior layer is then cut across, the clamps having first been attached to the upper end of the sac. The lower end of the sac can then be dissected out if it does not communicate with the tunica vaginalis; if it does, it is dissected down until the testis is reached, a purse-string suture is placed around the distal portion and the remainder removed. The proximal end of the sac is dissected upward until it widens out into the peritoneal cavity. At this point the sac is transfixed in the centre with a double No. 1 plain catgut ligature, and then tied off, so that there is no longer any funicular process of peritoneum. The cord is then held up by means of a strip of tape and clamp and the first row of buried sutures inserted as follows: The cord is held upright and the first suture, of medium-size kangaroo tendon (not too large), is introduced by means of a curved Hagedorn needle through the upper portion of the internal oblique muscle coming across the inguinal canal so that it just touches the lower border of the cord when the latter is held vertically to the plane of the abdomen. The suture is passed outward, first picking up the cremaster muscle, and then the shelving edge of Poupart's ligament, and is finally tied.

The second suture is placed in exactly the same way, one-half an inch below. The cremaster muscle is included in the first two sutures, thus affording additional strength to the deep layer. The benefit of thus utilizing the cremaster was first pointed out many years ago by Halsted of Baltimore. We believe it to be of considerable advantage.

Four sutures are usually required in adults. The fourth is perhaps the most important suture of the whole operation and is inserted in a special way, as follows: The external oblique is reflected inward and the ilio-inguinal nerve, which up to the present time is held on the inner side by a retractor, is now released and allowed to drop back into its normal place. The reflected portion of the external oblique about one-half an inch above where it meets the conjoined tendon is transfixed with a sharp Hagedorn needle. The needle then crosses over the nerve and picks up the outer portion of the conjoined tendon, crosses over beneath the cord and enters the lower part of Poupart's, close to its attachment to the pubic spine. The tighter this suture is drawn the more room there is for the underlying nerve which can never be compressed. This is essential, as a great deal of neuralgic pain which often follows hernia operations is undoubtedly due to this nerve

having been caught in the sutures. When this suture is tied the lower portion of the inguinal canal is completely closed up to the pubic bone. This stitch is not a part of Bassini's original technic, but we believe it has distinct advantages and greatly lessens the number of recurrences.

Another modification in the Bassini method, which we have used the last twenty-five years, is inserting one suture above the cord, passing it through similar structures to those below, making a new internal ring exactly sufficient for the cord to pass through without undue constriction, and, on the other hand, of sufficient size not to favor a recurrence. The aponeurosis is then closed from above downward by means of a continuous suture of fine kangaroo tendon, leaving just sufficient space at the lower end for a new external ring through which the cord emerges.

The operation for inguinal hernia in the female is precisely the same as the operation we have just described, except that the round ligament is preserved and not transplanted.

Femoral Hernia.—The method employed in practically all cases of femoral hernia has been the simple, so-called pursestring, operation, consisting of first a very thorough removal of all the overlying fat which, in many cases of femoral hernia, completely surrounds the sac and makes it somewhat difficult to find the latter. Second, a very thorough freeing of the sac, pulling it down so that it is possible to place the ligature well beyond the neck, and finally, the closure of the femoral canal by means of a pursestring suture of kangaroo tendon. Using a curved Hagedorn needle the suture is placed as follows: The needle is first passed through the inner portion of Poupart's ligament or the roof of the canal, then downward, taking firm hold of the pectineal fascia and muscle, then outward through the fascia lata overlying the femoral vein, and finally upward, emerging through the roof of the canal about one-quarter inch distant from the point of entrance. When this suture is tied the floor and the roof of the canal come into easy apposition and the femoral opening is completely obliterated.

Umbilical Hernia.—The Mayo method of overlapping was adopted at the Hospital for Ruptured and Crippled soon after it was published in 1898, and our results, we believe, show it to be superior to all other methods.

The main principles of the operation are:

1. Transverse elliptical incision, including the umbilicus and, in very obese people, a considerable amount of redundant skin and underlying fat. This incision is carried down to the aponeurotic layer. Instead of incising the sac over the distal or most protuberant portion, the opening is made near the neck of the sac, or, rather, just outside of the aponeurotic ring from which the sac emerges. The reason for this is that in most cases of large umbilical hernia the sac contains great masses of irreducible omentum which are apt to be adherent to the distal portion of the sac, while the sac in the neighborhood of the aponeurotic ring is quite free from adhesions. Hence, if the incision is made at this point, there is no danger of injuring the contents of the sac.

2. If adherent omentum is present within the sac, it is freed from these adhesions and removed, care always being taken to tie it off in very small sections with catgut ligature. The fascial ring of the sac is then enlarged on either side by a transverse incision; the overlying fat is carefully dissected from the anterior surface of the aponeurotic layer for a distance of 2 to 3 inches. The wound is then closed by a series of interrupted mattress sutures of medium-size kangaroo tendon or with chromicized catgut, placed in the following manner:

A Hagedorn needle with kangaroo tendon of medium size pierces the upper flap 1 to 2 inches from its margin, passing through the entire thickness of the aponeurosis and peritoneum and then transversely through the whole thickness of the lower flap about ¼ inch from its margin; on returning it is passed through the under surface of the upper flap, the same distance from the margin and 1¼ inches distant from the point of entrance. A sufficient number of sutures are passed in this way to completely close the opening. It is advisable to insert all the sutures before tying any. When these sutures are tied, the upper flap will overlap the lower 1½ to 2 inches. The edge of the upper flap is then fastened with a continuous suture to the anterior surface of the underlying lower flap. This makes a firm double barrier to guard against recurrence.

Undescended Testes.—The method of operation in cases of undescended testis consists in free incision of the external oblique—as in the Bassini method of operation. The sac in all cases of undescended testis is extremely thin and the dissection must be made with great care. After the sac has been cut across, just above the testis, it is freed well up beyond the internal ring and tied off as high as possible. The lower end of the sac is sutured over the testis, making a complete tunica vaginalis. The next step is to remove all the fascial bands which surround the veins. When this has been done, it is usually possible to bring the testicle into the scrotum. In the few cases in which it is not possible, the majority of the veins may be resected, leaving a little more than the vas and the spermatic vessels. This step was advocated by Doctor Bevan many years ago, and has proved of very great value. In a very small number of cases gangrene of the testis is reported to have occurred, but we have not seen it in our experience. It should never be used as a routine measure, but only in the rare cases described. The cord is never transplanted, but allowed to drop back in the lower angle of the wound; the internal oblique is sutured to Poupart's ligament, exactly as in inguinal hernia in the female. We do not suture the testis in the scrotum as advocated by many surgeons.

In the majority of our cases the testis has remained in the lower or middle scrotum, but in a considerable number it has retracted to the region of the external ring. In a few cases in which the testicle was of normal size at the time of operation, it continued to develop in the normal manner after operation, but in the cases in which it was more or less atrophied at time of operation, it failed to increase in size after operation. In only two

cases was the testis removed at the time of operation. It was so atrophied that it was almost impossible to recognize any testicular elements. Whether or not the undescended testis is of functional value, is a problem which has not yet been settled. There are a few cases on record of patients with double undescended testis, that apparently have been able to produce children.

There have been no deaths in this series of 441 cases and no hernia has thus far been known to follow the operation.

The results in this group of cases might be used as an argument in favor of not transplanting the cord in the ordinary inguinal hernia in the male. However, it is hardly fair to draw this inference, for the reason that in the great majority of these cases the hernia was rather a potential one, than an actual hernia, being merely an open process of peritoneum, communicating with the abdominal cavity and tunica vaginalis.

Direct Hernia.—Far back in the early days of radical operation it was recognized that it was much more difficult to effect a permanent cure in direct inguinal hernia than in the oblique type. Special modifications of technic have been devised to meet these difficulties. Wölfler in 1892 introduced a somewhat complicated technic in which the rectus was turned out of its sheath anteriorly and sutured to Poupart's ligament. Bloodgood in 1898 published a modification of Wölfler's method and later advised opening the rectus sheath from behind. For many years we have held to the belief that the transplantation of the rectus muscle is almost essential to a permanent cure in direct inguinal herniæ, particularly those of large size, and in our opinion the method described by Dr. William A Downes (ANNALS OF SURGERY, 1911, vol. liii, p. 568) is the best thus far proposed for utilizing the rectus muscle. Unlike Slajmer, we believe transplantation of the cord is not only the method of choice in oblique inguinal hernia but of even greater importance in cases operated upon for direct inguinal hernia.

The method of operating on direct hernia as advocated by Doctor Downes is briefly as follows: First, removal of the indirect and direct sacs, with division of epigastric vessels; second, the internal oblique and transversalis are held up by a small blunt retractor placed at the internal ring, and these muscles are followed, down and in, until they join the transversalis fascia at the outer margin of the rectus. The sheath of the rectus formed by these structures at this point is opened, and the muscle is exposed down to its pubic attachment. By means of three sutures of kangaroo tendon the outer margin of the rectus muscle is sutured to Poupart's ligament. The sutures are placed from below upward, and about one-half to three-quarters of an inch apart. In some cases four sutures are necessary. After this row of sutures has been completed the retractor is withdrawn and the usual Bassini operation performed from above downward, the internal oblique muscle being sutured to Poupart's ligament. The sutures in this case are just superficial to and between the first row. The external oblique is then closed in the usual way. There are three distinct layers instead of two as in the operation for oblique hernia. The cord is always transplanted and the cre-

master if not too thin is included in the sutures uniting the rectus with Poupart's ligament. Up to the time of his report Doctor Downes had performed the operation in 50 cases of direct hernia; 10 had been traced for more than one year, having no relapses.

Further observation has, however, shown a certain number of relapses in the cases of Doctor Downes, and at present he is inclined to believe that as high a proportion as 10 per cent. of recurrences will be found even after this method, if the cases are traced to final results. In our own series Doctor Downes' technic has been employed only in a limited number of cases. Our aim has been to bring over to Poupart's ligament the anterior portion of the rectus muscle and rely upon the special stitch which we have already described for closing the lower portion of the canal, which includes the reflected portion of the external oblique. This avoids the extra layer of suture to Poupart's ligament in Downes' technic. In many cases Poupart's ligament is so poorly developed and easily torn that the insertion of two layers may weaken the structure upon which we most rely for our repair of the canal.

Within the last twelve months one of the writers (Hoguet) has discarded this method of operating on direct hernias, and is trying out a new one which differs in several essential points. The indirect sac which, although very small in some cases, practically always exists, is first separated from the cord and opened. The deep epigastric vessels are not divided, but by traction outwards on the indirect sac, practically all the peritoneum of the direct sac can be pulled externally to the deep epigastric vessels. By this method of treatment the danger of injuring the bladder when the direct sac is opened is obviated. Instead of suturing the rectus down to Poupart's ligament, the deep sutures are introduced in the manner described for the innermost suture in the Bassini operation, that is, instead of grasping only the conjoined tendon, this structure together with the reflected portion of the aponeurosis of the external oblique is included within the deep sutures, the cord, of course, being transplanted. Over this the cut edges of the aponeurosis are sutured, anterior to the cord. None of the cases operated upon by this method have recurred up to the present.

In spite of the most careful technic the proportion of recurrences in direct hernia will always be considerably greater than in the oblique variety. One of the chief reasons for this lies in the fact that most cases of direct hernia occur in adult males with poorly developed abdominal walls and, especially, poorly developed internal oblique muscles. If the final results of the patients who have been operated upon for direct hernia are carefully followed up for at least a period of two years after operation, we believe that fully 10-15 per cent. will show a distinct recurrence.

Suture Material.—There is one very important point of technic which has an equal bearing upon all methods of operation for the radical cure of hernia and that is the material used in the buried sutures. Upon this factor often depends the success or failure of the operation. At the Hospital for

Ruptured and Crippled we have had an unusual opportunity for observing the end results of many methods of operation and as early as 1890 to 1895 we began to see the increasing number of cases in which the disadvantages of using the non-absorbable sutures became very apparent. Since that time in the annual review of Hernia for Progressive Medicine Coley has repeatedly called attention to these disadvantages and strongly urged against the further employment of non-absorbable sutures and buried sutures. In the early days, or twenty-five years ago, there was some excuse for their use because of the difficulties attending perfect sterilization of absorbable sutures. However, since those days it has been possible to obtain entirely reliable sterilized kangaroo tendon or chromic catgut. And there has been no further legitimate reason for the use of non-absorbable sutures in hernia. The suture that lasts more than three weeks is a disadvantage rather than an advantage, inasmuch as if there be any tension at the end of this period the suture will cut through until the tension ceases to exist, when it will remain either as a harmless foreign body or, as is the rule in a not inconsiderable number of cases, will give rise to chronic irritation ending in an open sinus which persists until the foreign body has been removed. That these objections are not merely theoretical has been proven by a long series of observations. One of the most noteworthy cases illustrating this point was observed at the Hospital for Ruptured and Crippled in 1890, in which a silkworm suture had been used in a Bassini operation for inguinal herina in an adult man, six months before, and the wound had healed by primary union. At the end of this time a sinus formed and a suture was removed and the wound healed. He remained well for about two years, when another sinus appeared; another suture was removed, and the patient remained well until three years and eight months later, when a third sinus formed, at which time the last of the sutures was removed. In addition to the discomfort attending these various periods of sinus formation, the long continued suppuration with the consequent scar tissue served to produce a relapse of the hernia.

In spite of the fact that such results have been frequently published and are generally known, silkworm sutures are still used in operations for the radical cure of hernia by some of the most distinguished surgeons here and abroad. Only a year ago a patient was sent to us for a sinus in the right groin and another one in the left upper scrotum, with the history, that, about a year before he was operated upon for a hernia and varicocele at one of the most prominent English clinics. The patient was told that in five weeks he would be ready for military service. At the end of five weeks a sinus appeared and remained open for about six months, and he was told he would never be able to go into the army, so he came to America. The induration in the left scrotum with sinus formation so closely resembled tuberculosis that this diagnosis was made in one of the out-patient departments in New York. It was not difficult to make a diagnosis that buried or non-absorbable sutures were responsible for his condition. The sutures were removed and the sinuses promptly healed, but not until the young man

had been more or less of an invalid for nearly a year and until he had lost all opportunity of entering the army. The matter is so important that we have felt justified in again referring to it at such length.

From December, 1890, to January, 1918, 6090 operations for the different varieties of hernia have been performed at the Hospital for Ruptured and Crippled. The great majority of these operations were performed by a small group of surgeons—Doctors Bull, Coley, Walker, Downes and Hoguet, a small number by the assistant surgeons or house surgeons under our direct supervision.

VARIETIES AND RECURRENCES

	Cases	Recurrences	Per cent.
Inguinal in the male, oblique	4420	25	.57
Direct hernia, male	33	0	.0
Inguinal in the female, children	690	1	.15
Inguinal in the female, adults	369	13	3.5
Direct hernia, female, adults	13	1	7.7
Femoral hernia in children	69	0	.0
Femoral hernia in adults	182	8	4.4

Four of these recurrences were in cases in which the operation was done for recurrent hernia, the primary operation having been done by other surgeons. They should, therefore, not really be included.

Umbilical hernia, children	58	0	.0
Umbilical hernia, adults	104	3	2.8
Ventral hernia, children	24	0	.0
Ventral hernia, adults	81	12	14.8

NOTE.—Most of these were large ventral hernias in stout women, following old laparotomies.

Epigastric hernia	18	1	5.5
Lumbar hernia	1	0	.0

In 334 cases the operation was for undescended or maldescended testis. In practically all cases, with 3 or 4 exceptions, there was a hernia, either actual or potential, that is, an open funicular sac communicating with the tunica vaginalis.

It is noteworthy that not a single relapse has been observed in these 334 cases of operation for undescended testis.

Methods of Operation.—The typical Bassini operation, or the Bassini with slight modifications which have been described, was performed in inguinal hernia.

Inguinal Hernia—	Cases	Recurrences	Per cent.
Bassini	3725	14	.38
Cord not transplanted	792	11	1.3
Direct inguinal hernia, Bassini	24	0	.0

NOTE.—It should be stated that these cases of direct hernia all occurred in adult females and in children under the age of fourteen years.

	Cases	Recurrences	Per cent.
Transplanting rectus	8	0	.0
Femoral Hernia—			
Femoral, children	69	0	.0
Femoral, adults	182	8	3.1

NOTE.—It should be noted that four of the recurrences were in operations for recurrence.

The pursestring suture with kangaroo tendon was used in nearly all the cases, after a very high ligation of the sac and the removal of all the overlying fat.

Umbilical Hernia—	Cases	Recurrences	Per cent.
Umbilical hernia, vertical overlapping	34	2	5.8
Umbilical hernia, transverse or overlapping	77	1	1.8

A study of the time of the recurrence, *i.e.*, the interval between operation and the time that the recurrent hernia was noted, is of very great interest and importance. In 4453 cases of inguinal hernia in the male, 25 recurrences were observed, and of these 13 occurred within six months to one year after operation, three within one to two years. The other cases recurred at longer periods after operation: 1 after three and one-half years; 2 after seven years, 2 after three years; 1 after four years; 1 after fourteen years and 1 after twenty years.

Mortality.—The mortality has changed very little since the earlier statistics. From December, 1890, to January, 1901, a period of ten years, 2732 cases were operated upon at the Hospital for Ruptured and Crippled, with six deaths, or .22 per cent. From January, 1901, to January, 1918, 3358 were operated upon with five deaths, or .15 per cent. The later deaths referred for the most part to cases of large irreducible strangulated umbilical hernia. They were as follows:

End Results.—With regard to the end results of the first period, we find 15 recurrences in 2029 cases of inguinal hernia in the male, or .73 per cent. in the cases operated upon by the Bassini method, and 42.8 per cent. in the small group of cases operated upon by Czerny's method.

In the second period, from 1901 to 1918, covering 220 cases, there were only 10 relapses or .45 per cent.

CASES OF INGUINAL HERNIA OBSERVED AT THE HOSPITAL FOR RUPTURED AND CRIPPLED

	AGE									
	Under 1 yr.	1–4	5–9	10–14	15–19	20–29	30–39	40–49	50–59	60–
Male	4	790	1929	833	34	18	28	7	7	3
Female	..	86	322	150	60	84	86	47	18	18

In this series, as far as it has been possible to trace, 1667 cases have remained well from one to four years; 586 cases have remained well from five to nine years, 193 cases have remained well from ten to fourteen years, 46 cases have remained well from fifteen to nineteen years, and 14 cases have remained well from twenty to twenty-six years.

Of 216 cases of femoral hernia, 169 have occurred in adults and 47 in children under the age of fourteen years. Ninety-nine cases have been traced in which the patients have remained well from one to twenty-four years after the operation, and in the entire series 14 recurrences are known to have taken place.

Of 166 cases of umbilical hernia, 118 occurred in adults and 48 in children; of the latter, 21 occurred in males and 27 in females. In 66 cases the patients are known to have been in good condition from one to eleven years after the operation, and in 25 cases for more than three years. Nine recurrences have taken place and 5 deaths—among the deaths was one case, a female forty-four years of age, in which an extensive operation for carcinoma of the ovary was performed in addition to the hernia operation, and the patient died four days later.

Of 103 cases of ventral hernia, 86 occurred in adults and 17 in children. In this series 41 have remained well from one to fifteen years, the remainder not having been traced, and 11 recurrences have taken place.

Of 15 cases of epigastric hernia, 12 have occurred in children under the age of fourteen years, and the remainder in adults. Six cases are known to have been well from one to seven years after the operation, and in two cases a recurrence took place.

Direct Inguinal.—There have been observed at the Hospital for Ruptured and Crippled, 54 cases of direct hernia, including 4 doubles, making a total of 58 cases of direct hernia. Of these, 37 cases occurred in adults (21 in females and 16 in males), and the remainder in children under the age of fourteen years. As regards the sex in the latter, all occurred in males with one exception. These figures, however, do not represent the actual relative porportion occurring in the two sexes. It is only the last year that adult males have been admitted to the Hospital for Ruptured and Crippled. Direct hernia in the female is extremely rare and the relative proportion is more accurately shown in our statistics elsewhere. The final results in this list of 58 cases is of interest. In only one case is a recurrence known to have taken place. This case was complicated with a separate interstitial sac coming out of the internal oblique external to the internal ring and not connected with the round ligament; a recurrence took place seven months after the operation. Of the cases that have been traced, 18 have remained well from one to eight years.

The final results in the cases of undescended testis will be given in detail in a separate paper. A brief summary of the cases observed at the Hospital for Ruptured and Crippled is as follows:

Of 314 cases of undescended testis only 10 occurred in adults over the age of fourteen years. As far as can be traced 123 cases have remained well from one to twenty-one years after the operation, 64 cases over three years, and 14 cases over ten years. It is interesting to note the position of the testis in these latter 14 cases. In one case, well twenty-one years, the testis was atrophied; in another, well thirteen years after, the testis was not

felt; in another, well fourteen years, the testis was outside of the external ring, and the size of a hickory nut; in another, well eleven years, the testis was not felt; in another, well eleven years, the testis had disappeared; in one case, well twelve years, the testis was normal in size and position; in another case, well twelve years, the testis was small and at the spine, and in another case, well twelve years, the testis was in the channel; in one case, well eleven years, the testis was atrophied and lying on the external oblique just above the external ring, and so on. In the 2499 cases operated on outside the Hospital for Ruptured and Crippled, there were 107 cases of undescended testis.

This large group of cases should throw some light upon the important question of whether the trauma connected with bringing the testis into the scrotum by operation favors the development of malignant disease. As far as we have been able to determine, in no single case in our series has the patient afterwards developed a sarcoma of the testis. One of the authors, however (Coley), has observed a case of sarcoma in an undescended testis shortly after an operation had been performed for bringing it into the scrotum. The patient was operated upon in another city and it is impossible to state positively that the disease had not been fully developed before the operation, although, in all probability, in this case the trauma connected with the operation may have been an exciting factor.

Strangulated Hernia.—Of the 31 cases of strangulated hernia observed at the Hospital for Ruptured and Crippled, it is interesting to note that the majority occurred in children under the age of two years. The youngest case was a child thirteen days old, with a loop of small intestine fourteen hours strangulated. A Bassini operation was performed and the patient was well when last traced, many years later. Seven of these cases were under one year of age, and 10 under two years. It is especially worthy of note that the only death in this series occurred in a woman fifty-one years of age, with a very large strangulated umbilical hernia. The only recurrence which took place was in a woman thirty-five years of age with a very large strangulated umbilical hernia which was complicated by a seven months' pregnancy. A hernia operation was performed and was followed by severe suppuration of the wound, which, together with the unusual strain of child-birth coming on two months later, favored a recurrence of the hernia, which took place eight months after the operation. Thirteen of these cases traced were found to be free from recurrence from one to twelve years after operation.

Contents of the Hernial Sac.—The cæcum alone and with the appendix was found in 27 cases; in one case there was a slight relapse one year after the operation, of the remainder as far as were traced 12 remained well from one to twenty-one years after the operation.

The appendix was found in the hernial sac in 39 cases. In all but three of these, the age of the patient was under fourteen years. In 8 of the earlier cases the appendix was not removed, but in the remaining 31 cases the appendix was removed at the time of operation.

The ovary and tube were found in 9 cases; the tube alone in 4 cases, and the ovary alone in 4 cases. One case of special interest is that of a woman thirty years of age with a double strangulated hernia in which a strangulated (fallopian) tube was found in the right femoral sac; the patient was well and free from recurrence when last traced, eight years after the operation.

In 17 cases the bladder was found in the sac; 10 of these cases occurred in children under the age of fourteen years, and 7 in adults between the ages of twenty-five and sixty-five years. In every case, with one exception, the bladder was recognized before it had been opened. This particular case occurred in a woman thirty-seven years of age with a left femoral hernia; the patient made a good recovery without complications.

Seven cases of tuberculosis of the hernial sac were found, in all of which the diagnosis was confirmed by pathological examination. One of these cases died of tubercular peritonitis some time after, 1 was well four years later, and the remaining cases were not traced.

The results at the Hospital for Ruptured and Crippled have been often criticised as not furnishing a true criterion of the value of the radical operation for hernia, because so large a proportion of the cases have been in children under the age of fourteen. It is assumed without debate that it is much easier to effect a cure of hernia in children than in adults. Although our statistics at the Hospital for Ruptured and Crippled prior to 1890, when the older methods of Czerny and Socin were employed, show practically the same proportion of recurrences in children as in adults, we believe that children and young adults are more favorable subjects for operation than older people. In order to throw further light on this question, we have included 2499 cases of adults operated upon by Doctors Coley and Hoguet outside of the Hospital for Ruptured and Crippled and in Doctor Coley's service at the Memorial Hospital by Dr. Wm. A. Downes; of these 2499 cases, 1383 were operated upon by Coley and Downes, 595 were operated upon by Hoguet, and 521 were operated upon by Coley.

AGE OF PATIENTS, INCLUDING MALES AND FEMALES.

Under 5 years	54
5–10 years	31
10–20 years	394
20–30 years	889
30–40 years	549
40–50 years	358
50–60 years	170
60–70 years	54
Total	2499

Inguinal hernia in the male—oblique	1855
Inguinal hernia in the female—oblique	182
Inguinal hernia in the male—direct	252
Inguinal hernia in the female—direct	5
Femoral hernia	101

Umbilical hernia	65
Ventral hernia	32
Epigastric hernia	7
	2499

Among the local sequelæ following radical operations for hernia are: hydrocele and orchitis. Among the general sequelæ: bronchitis, pneumonia, phlebitis, intra-abdominal swelling due to inflammation of omental stump and embolism.

We believe that the local sequelæ are in direct proportion to the experience of the operator. If great care is exercised in dissecting the sac from the cord with a minimum of trauma, the larger vessels tied before cutting and the small bleeding points controlled by ligature, hydrocele, orchitis, or local swelling will very rarely be observed. We always support the testis by a little shelf or platform made of adhesive plaster placed across the upper portion of the thigh. Following operations for hernia we have observed (?) cases of pneumonia undoubtedly due to the anæsthetic.

The frequency with which thrombosis and embolism is the cause of death in abdominal operations is brought out by E. H. Beckman (ANNALS OF SURGERY, May, 1913) and L. B. Wilson (ANNALS OF SURGERY, December, 1912,), both of the Mayo Clinic. Wilson states that during the period from 1899 to 1911, inclusive, 63,575 major operations were performed with 47 cases of fatal post-operative embolism, these fatalities representing 5 per cent. of the total number of deaths from all causes.

It is somewhat remarkable that thus far there have been no deaths from embolism in our series of 6500 operations performed at the Hospital for Ruptured and Crippled.

In 1383 cases operated upon at the Memorial Hospital by Doctors Coley and Downes, there were two deaths. In the first case, a male thirty-five years of age, operated upon by Doctor Coley, a large mass of omentum was replaced with some difficulty and probably considerable trauma. The patient died on the fifth day with gradually increasing distention and signs of peritonitis. The second case, operated upon by Doctor Downes, died of infection and peritonitis. In a third case operated upon by Doctor Coley at the Memorial Hospital—a very large irreducible umbilical hernia in a stout woman—death occurred. It was found almost impossible to reduce the contents of the sac into the abdomen and when reduced respiration became difficult. The patient died two days later of heart failure; no evidence of sepsis. Another death occurred in a case operated upon at the Post-Graduate Hospital by Coley in 1895, in a strangulated femoral hernia with resection of the bowel.

Doctor Hoguet's series shows 6 deaths: two males, one a strangulated indirect hernia with general peritonitis present at time of operation, and the other a simple indirect acute, with atrophy of the liver; and four females, one a strangulated femoral, no resection, shock; another, a strangulated femoral, after gut resection; another, a direct inguinal, acute nephritis; and the fourth, a ventral with pulmonary embolism.

LIPOMA OF THE FUNICULUS SPERMATICUS

By Heliodor Schiller, M.D.
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Lipomata in the wake of the inguinal canal are common. Kellogg Speed found in 154 hernial operations 75 lipomatous growths which had their origin in the properitoneal fat. They spring from the subserous fat around the margin of the internal ring, singly or several of them, and if enlarging grow along the inguinal canal, distending it, and often follow the cord as far as the scrotum. They vary in size up to many pounds, have at times a distinct peritoneal-like capsule, are in many cases the predisposing cause of hernia, not only by distending the internal and external rings and inguinal canal, but because they will, by propulsion, produce an infundibulum in the peritoneum and thus a hernial sac. Mention should also be made of the fatty hernias, in which the sometimes small hernial sac is enveloped by thick masses of fatty tissue.

The true lipoma of the cord is a rare tumor and originates from fat lobules within the tunica vaginalis communis of the cord around its different organs. Small fat lobules within the cord are sometimes to be seen macroscopically—in 22 cases which Hutchinson examined in this direction, he could find small fat lobules in 11 cadavers—microscopically fat tissue can be detected within every cord. The size of the lipomata varies from a small tumor to an enormously large growth. It may extend proximally up to the internal ring, ending there sharply or connecting intimately with the properitoneal fat. Distally it may grow as far as the scrotum and by breaking through the tunica vaginalis propria, as far as the epididymis and testicle, and attain great size. A few cases are reported where the lipoma broke through the tunica communis and connected with the fat of the subcutaneous tissue, in this way disguising the real origin.

The pathologic anatomical differential diagnosis between the true lipoma of the cord and the common lipoma of the subperitoneal fat in their early stages is simple, but later on often impossible. If small and well encapsulated there can be no doubt of their origin, but if the lipoma is large, even a wide exposure will not assist. Theoretically the lipoma of the cord should always be surrounded by the tunica vaginalis communis, it should derive its main blood supply from the vessels of the cord, while lipomata from the properitoneal fat always should show a close connection with this layer and should get its blood supply from there and should lie outside of the tunica vaginalis communis. But the true lipoma of the cord will often break, in the course of its growth, through the tunica communis, especially in the proximal part of the inguinal canal, where the cord normally is spread, will connect there so closely with the subserous fat that it appears a lipoma of it.

Clinically there are, depending on the size and location, all the symptoms of a hernia, respectively omental hernia, a soft tumor in the inguinal canal or extending down in the scrotum, showing impulse on coughing, enlargement in the erect position, a tumor which can partly be replaced into the abdomen. If the lipoma grows more toward the scrotum, a hydrocele, hæmatocele, teratoma, tumor of the testicle, cyst of the cord, hydrocele of the funiculus have been mistaken. Their consistency differs from pseudo-fluctuation to rather hard tumors, depending on the amount of connective tissue present. For the surgeon it is well to remember that the lipoma of the inguinal canal often contains a peritoneal sac, also to remember the fat hernia with a comparatively small hernia sac and a great accumulation of fat around it. The small sac might hardly be detectable and nevertheless contain an abdominal viscus.

The treatment is surgical. After removal of the lipoma, it will be advisable to finish the operation with a radical operation for hernia. Pressure and traction causes these lipomata gradually to distend the rings or the inguinal canal, thus predisposing to or actually producing a hernia. Therefore the radical operation becomes a necessity.

A man, forty years old, tall, heavy—210 pounds—always well, noticed for over a year a slow-growing swelling in his right inguinal region, which was diagnosed as a hernia. For the last six weeks it gave him discomfort. The examination showed a healthy man with well-developed panniculus adiposus. In his right inguinal canal and extending down in the scrotum is a sausage-like, soft tumor enlarging the scrotum twice the size of the other side; the tumor, enlarging in the erect position, shows impulse on coughing, but cannot be entirely pushed into the abdomen; this attempt is painful. After incision of the skin, subcutaneous fat, superficial fascia, the fibres of the cremaster could be seen spreading over the supposed hernia. After separating them bluntly a well-developed membrane, like the peritoneum of a hernial sac, could be made out, and shining through it a large mass of fat extending into the scrotum. This whole mass and sac could easily be enucleated from the scrotum. After incising the membrane doubt arose that we were dealing with an omental hernia, large fatty lobules grew around the vessels of the plexus, spreading the contents of the cord like a fan, carrying them on its medial side, while in the proximal part of the canal the fatty mass ended rather abruptly, surrounded by a well-defined, capsule, only a few strings of connective tissue connecting it with the subperitoneal fat. The contents of the cord were finally separated from the lipomatous mass, several blood-vessels connecting with the plexus had to be ligated and, as the inguinal canal was left very wide, no peritoneal bulging could be noticed—and as the abdominal muscles were widely separated from Poupart's ligament, an Andrews' operation was performed. The specimen shows a lipoma 6½ inches long, the circumference of the upper end 4, and of the scrotal part 6 inches,

having the character of the lipomata of subcutaneous fat. The above described anatomical findings make the diagnosis of a true lipoma of the funiculus spermaticus certain.

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FECAL FISTULA FOLLOWING STRANGULATED HERNIA, WITH REPORT OF FIVE CASES OPERATED UPON

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Practically all cases of strangulated hernia unrelieved by operation invariably terminate fatally from peritonitis or shock. A small proportion, however, generally estimated at about 5 per cent., recover. In rare cases the destructive process will penetrate the sac and skin, and the patient will recover with a fecal fistula and artificial anus. Adhesions doubtless form between the strangulated loop of intestines and the wall of the sac. The hernial protrusion becomes red, tense and sensitive. Compression anæmia of the intestine plus infection of the damaged loop results in gangrene and rupture, and the abscess finally ulcerates through the hernial sac and integument. Meanwhile the entire process has been walled off from the general peritoneum and self-cure is obtained by external perforation without peritonitis.

Five such cases have occurred in my service. Four were women, of whom two were middle-aged and two were elderly, the other was a boy of six. Three were femoral and two were inguinal. The period preceding perforation was from ten days to two weeks. Two ruptured spontaneously, and three were opened for the resulting abscess. All drained fecal matter. Two healed naturally in four and five weeks respectively after evacuation of the abscess, two after freshening the margins of the opening, and one required abdominal section with detachment of the intestinal loop from its entrapped position in the femoral ring and suture of the opening. All recovered.

Case I.—About twenty years ago Doctor McClarny, of Crossville, Tenn., sent a large fleshy woman to me with a fecal fistula in the right groin. It had been discharging three or four months. There was a history of a femoral hernia for some years, for which a truss had been worn. The hernia had become strangulated and living across the mountain she was unable to obtain surgical or other attention. After great suffering the herniated mass became exquisitely tender and at the end of two weeks ruptured spontaneously. The contents of the bowels escaped at the site for some months when she was sent to the hospital for relief. About that time we were having a number of persisting biliary fistulæ after operation on the gall-bladder, as we were sewing the gall-bladder to the abdominal fascia. They were readily cured by making a circular incision around the margins of the fascial opening, allowing granulations to form between the freed margins of the gall-bladder that had been liberated from its attachment to the fascia. This idea was utilized in this case, with prompt and satisfactory healing.

CASE II.—A lad of six awakened crying with pain, and told his mother that the knot had come back in his side. Eighteen months before, the hernia had been irreducible for about a week, but there were no obstructive symptoms then or later. There were swelling, pain and vomiting. Normal defecation occurred on the first and second days and purgatives were given, and acted on the third and fifth days. Pain was considerable and the boy was confined to bed. Temperature appeared on the second day and continued. The swelling gradually increased. Topical applications were made, and on the seventh day it was poulticed. On the following day it appeared red and looked like an abscess, ready to be opened. On the ninth day Dr. W. T. Green, of Big Rock, Tenn., incised it. Considerable pus escaped and then several ounces of liquid fæces ran out. The little boy was brought to St. Thomas Hospital on the seventeenth day (January 16, 1913), where the incision in the right inguinal region was enlarged and what appeared to be a sphacelous knuckle of intestine about two inches in length was lifted out.

The fecal fistula remained for about four weeks and closed spontaneously. The boy has been quite well since.

CASE III.—A woman, Mrs. Joe A., sixty-three years of age, entered the hospital December 7, 1916, with a discharging sinus and fecal fistula in the left groin of three months' duration. At that time she had noticed a slight femoral enlargement about the size of the end of the thumb. Within a few months she had two attacks of general abdominal pain with nausea, vomiting and constipation, followed by soreness and tenderness over the abdomen for several days. Three months ago she was seized with vomiting, cramping pains in lower abdomen, followed by a chill, fever and sweat. Vomiting persisted for forty-eight hours. No bowel action for five days; abdominal pain the while, with visible peristalsis. The femoral enlargement increased to the size of two fists. At the end of two weeks the tender mass ruptured and discharged a large quantity of pus which was later followed by fecal material. This continued until two weeks ago, since which time the discharge was pus in moderate amount. Forty years ago she had a number of pulmonary hemorrhages, and has lived in Montana on that account with great improvement. There had been no hemorrhages for fifteen years.

The patient was kept in bed some two weeks and the sinus closed. She left the hospital and shortly the sinus reopened. Within two months she gained thirty pounds. The sinus alternately appearing to almost cease and then drain most profusely for a number of days. For several weeks peristalsis was noticeable and at times very active. Following a very severe attack of cramping, operation was advised for adhesion at the site of the former femoral fecal fistula. An incision in the left semilunar line disclosed the convex surface of a loop of small intestine firmly drawn into the femoral opening and densely adherent therein. It was separated with difficulty and the resulting rent at the site of the previous Richter's hernia with perforation was closed with two layers of silk. Recovery was complete.

CASE IV.—On the night of December 16, 1917, a woman, Mrs. C. E., fifty-eight years of age (No. A 6475), was admitted to the hospital with a very large abscess of the right groin of ten days' duration. The temperature was 102 degrees. The skin covering the abscess was mortified and black over a considerable area. The house-surgeon was about to open it when he discovered that it was tympanitic. When I opened it later, the gas escaped and the greatly distended skin covering collapsed. Some foul-smelling feculent fluid was evacuated. The wound drained fecal matter copiously the next morning and continued to do so for about ten days and ceased completely. The wide-open wound soon became healthy and granulating, and was closed under local anæsthesia on the fifteenth day.

CASE V.—Mrs. V., aged forty-five years, mother of seven children, lived in a sparsely settled community on the Cumberland Plateau. She had a hernia which became strangulated on October 1, 1903. Dr. A. F. Richards, of Sparta, was called to see her October 13th, and found her with pulse 140, temperature 103½, abdomen swollen to its fullest capacity, and the woman propped in a semirecumbent position, panting for breath. Her condition was extremely critical for several hours after the doctor's arrival, pending the use of stimulants and opiates. The hernial protrusion had sloughed and ulcerated through the right side, forming a fecal fistula through which gas and fæces poured. She gradually improved until November 18th, when the doctor found her with normal temperature and pulse, sitting up in bed, taking nourishment, but still having continuous fecal discharge from the fistula with an occasional normal bowel action. This continued until the following January, when I saw her, and opened the external fistulous tract, curetted the sinus and used stimulating applications, after which the fistula healed in about three months. She was seen some three years later by Doctor Richards, and was at that time entirely and completely well.

THE TRAUMATIC ABDOMEN*

By John B. Deaver, M.D.

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The stimulation to traumatic surgery brought about by the present war has extended to all branches of surgery, but it is essentially apparent in the field of abdominal work, for it is only exceptionally that the abdominal surgeon in civil life has the opportunity of extensive observation of this class of traumatism.

It is generally conceded, however, that there is distinction without difference in civil and war surgery of the abdomen. The same principles apply to both, paramount among them being early diagnosis and prompt treatment.

The apparently easy cases are generally the most difficult to diagnose. After the initial shock a reaction often sets in, which proves as deceptive to the patient as it is to the surgeon in attendance. Prostration, pallor, anxious facies, thirst, cold, exquisite pain on moving the body, limited abdominal movement on respiration, rapid pulse of low tension, rigidity, dulness in the flanks, vomiting—these are symptoms that leave little doubt of some visceral lesion; but often the picture is not so clear in spite of the presence of serious intra-abdominal injury. And again experience, especially with small particles of shell from an exploding bomb, has shown that one must be careful about making a negative diagnosis. The wound is often so small and insignificant while the velocity of the missile has been very great, that it sometimes takes actual "strength of mind" to explore the abdomen, although the symptoms point to the probability of visceral injury; oftentimes, too, a man hit in the abdomen is quite unconscious of the fact that the intestines are prolapsed.

In the early part of this war non-intervention was practically the rule in the treatment of abdominal injuries and the wounded were kept, in so far as this was feasible, as close as possible to the spot where the wound was received. With the perfection of the hospital and nursing service, a complete reversal of this principle was adopted, especially with the establishment of opportunity for prompt surgical attention reasonably close to the front, so important in this class of cases the mortality of which increases rapidly if treatment is delayed beyond twenty-four hours after the receipt of the wound. While operation is now considered the only chance of recovery in the vast majority of cases, though it sometimes represents only a minimum chance, there is a small percentage in which expectant treatment may be justified. These include mainly contour wounds and cases in which the projectile has apparently not traversed the abdomen but has been arrested

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in the immediate vicinity of the peritoneum, causing only reflex peritoneal reaction; abdominal wounds without visceral or vascular lesions, rare though not unknown; and wounds causing unimportant hemorrhage, as in perforation of a solid viscus, such as the liver, spleen or kidneys; and finally a few fortunate small actual perforations of the ascending or descending colon by the development of circumscribed peritonitis and a fistula.

With the exception of a few individual so-called "abstentionists" surgeons among our allies have ranged themselves with the "operationists," and to them an abdominal injury means incise, look for the damage and treat it. Even advanced cases of peritonitis and occasionally a pulseless patient have profited by operation when *abstention* would have meant certain death. The dictum seems to be: operate, operate early, operate as near to the front as possible, and make your operation as complete as possible.

Shock may be combated by the usual means, but too much time should not be lost in this measure. Symptoms of shock often do not appear during the first two or three hours, except in cases of profuse hemorrhage, or of effusion of intestinal contents into the abdominal cavity, so that shock does not necessarily contra-indicate operation. Moreover, the patients are usually young men whose physical resistance has been developed to a high pitch so that what might be venturesome in civil life proves less so in war conditions.

Interesting studies are being made on the subject of shock and hemorrhage. The importance of the question is evidenced by the appointment of special committees to investigate and coördinate the results of the studies made. From the reports that have thus far been published we gather that, although the underlying etiological factor in the production of symptoms of shock has not yet been determined, existing observations as to blood-pressure and physical changes in the blood have been confirmed and new ones have been brought forth, several groups of cases having been studied almost from the moment of being injured and at various stages before reaching the operating theatre as well as after operation.

Without in any way reflecting upon the value and the importance of these studies, I venture to question their practicability at this time, for the traumatic abdomen. Abdominal cases are emergency cases and there is rarely time, nor, I should think, the proper equipment, at the front for making these studies, necessary to decide whether a man is suffering from shock or hemorrhage or both, nor at the present time with the shortage of laboratory assistants in civil hospitals is it always possible to have such studies made.

Differentiation of shock and hemorrhage is a very delicate one. It is to be anticipated that the studies of the research committees, already referred to, will furnish very definite conclusions in this regard. The leucocyte count which is increased in hemorrhage and is not apt to be affected by shock often throws some light on the subject. But with the means at present

at our disposal much depends on the intuition of the experienced surgeon who more often than not makes the differentiation correctly.

In the diagnosis of a suspected abdominal lesion pain is of little aid. It varies in degree and there is apparently no direct relationship between its intensity and the extent of the injury. Pulse and the degree of abdominal rigidity are of importance. A man with a pulse of more than 110° is not usually able to withstand prolonged anæsthesia and requires suitable treatment before operation is undertaken. Hemorrhage should always be suspected and then it is the state of the pulse that is often the deciding factor for or against intervention. Abdominal rigidity varies from generalized rigidity over the entire abdomen to a small localized area. The latter often occurs in late cases where a lateral wound has involved only the colon, and a fecal fistula or walled-off fecal abscess has formed. The absence of rigidity is now generally recognized as an unfavorable prognostic sign, since it is usually associated with extensive lacerating lesions of the small and sometimes the large intestine and usually is seen in cases that come under observation from ten to twelve hours after being wounded.

Vomiting, though it forms part of the history of nearly every case of abdominal injury, is not a constant feature, in fact, it is often a prominent symptom where there is no visceral lesion. The same inconstancy characterizes hæmatemesis and melæna; when present they are valuable diagnostic signs, but their absence does not necessarily indicate the absence of perforation of a viscus.

Nor is the site of the wound an unfailing indication as to the involvement or otherwise of the abdominal cavity. A foreign body may enter almost any region of the body and traverse or lodge in the abdomen. The records of the present war injuries of the abdomen contain a surprisingly large percentage of cases in which a bullet entering the buttock has caused lesions of the cæcum or the pelvic colon, or where involvement of the kidneys, colon, liver and spleen has resulted from a foreign body entering behind a line extending from the mid-axilla to the anterior superior spinous process of the ilium.

A valuable diagnostic point is the consideration of the entrance and the exit wounds, where both are present, and the course and direction of the track, that is to say, the plane of abdominal involvement and the structures that may have been traversed. Intestinal injury, for example, may be taken practically for granted where the track of the bullet extends anteroposteriorly in the centre of the abdomen or where its course is transverse between the costal arch and the crests of the ilia. This type of injury is generally fatal, although a few exceptional recoveries have been reported. Intestinal injury likewise practically always results from contused wounds caused by localized violence, such as a sudden blow full on the abdomen or a fall from a height, or a weight falling on the abdomen.

Abdominal injuries, I repeat, are to all intents and purposes emergency cases and there is little time for elaborate preparation before the patient

reaches the operating table. The removal of the clothing, emptying of the bladder, washing the skin, preferably with a carbolic lotion or iodine, is about all that can be done in the majority of instances. Morphia and atropine are given hypodermically, and if possible one hour before the anæsthetic, preferably ether, is administered. Satisfactory results have been obtained with intravenous injections of bicarbonate of soda, just before the anæsthetic is given. The bicarbonate of soda not only counteracts the acidosis which is nearly always present, but at the same time reduces the concentration and the viscosity of the blood.

The incision is a matter of judgment on the part of the surgeon and will also depend on the suspected viscera involved, irrespective of the site of the wound. As a rule, however, a median or paramedian longitudinal incision is selected and should be ample so as to allow free access to the cavity, which in turn means rapid work. The value of X-ray demonstration of the location of the foreign body is well illustrated in those cases with only a single wound of entrance. It avoids unnecessary exploration of the entire abdomen, when a bullet has, for example, lodged in the loin, the only injury being a lesion of the colon to its peritoneal reflection; in which case the incision is made accordingly.

Opinions differ as to the value of drainage to the pelvis and the flanks. Some surgeons find nothing to recommend it, and they limit drainage to the use of a small drain carried down to the line of the sutured bowel, and thus provide a local track in case of leakage. Other surgeons drain in case of profuse hemorrhage where all oozing cannot be arrested, the best use of the tube in these instances being as a conductor for a tampon; also for possible leakage in wounds of the hollow viscera and when septic material has been extravasated and in cases requiring tamponage and temporary suture; also in stomach and colon lesions where there was much free blood in belly, or where, as often occurs in late cases, a free serous effusion had collected in the abdomen. It should be remembered that the peritoneum does its best work when unhampered, which means limited drainage, if any.

Lavage of the abdominal cavity is not generally advocated. Ether has been almost altogether abandoned for this purpose; satisfactory results with the use of warm serum have been reported but saline is the medium of choice. Personally I do not practice lavage, as a rule.

As to the involvement of one or the other viscus, it appears that in war injuries of the abdomen the small intestine is the most frequently injured. The mucous membrane from the one or several perforations prolapses through the rent in the form of rosettes, the eversion being due to contraction of the longitudinal coat. The damage is local, the mucous membrane being normal up to the rent. It is the multiplicity rather than the danger of sepsis that lends these wounds their serious character. Suture is the proper method of treating them; resection being reserved for cases with numerous perforations close together. Post-mortem observation thus far has shown no evidence of spontaneous healing of wounds of the small intestines.

The large intestine when wounded usually presents only a single tear or perforation rather than a complete section of the gut. The wounds of this viscus show a greater tendency to sepsis and sloughing than those of the small intestines. They are often extra-peritoneal, a notable feature being the extent of bruised surface, as seen in the collection of blood between the peritoneal and the external walls.

Colon wounds are characterized by their tendency to localization. Therefore if they come to operation later than twenty-four hours after injury it is advisable to enlarge the original wound with the idea that infection is localizing. If seen before that time a separate incision is the better procedure. Colotomy at the site of injury is required when the wound is extensive; otherwise suture reinforced by omental graft seems to be the chosen method. Suture combined with proximal colotomy has not found the extensive application that was expected. It proved to be superfluous, inasmuch as, the tissues being already infected, its primary object of limiting infection had already been forestalled, besides which the extra opening in the bowel is undesirable.

Wounds of the stomach are usually associated with injury to other abdominal viscera and often with lesions of the thorax. Peritonitis following a stomach wound usually develops slowly and runs a subacute course, except where bile has escaped from the stomach. Simultaneous perforation of the anterior and posterior wall often takes place, and as the latter is easily overlooked, careful exploration of the entire stomach through the intercolo-epiploic route is most important. It seems that suture is the preferred method of dealing with perforating gunshot wounds of the stomach. Gastro-enterostomy, with or without previous suture, is resorted to only for very extensive lesions or when the antrum or the duodenum is involved or where there is a narrowing of the stomach.

Wounds of the rectum, when extraperitoneal, are treated in the usual manner by establishing drainage after the wound has been opened up; and when intraperitoneal, by suture followed in certain cases by colotomy. If possible the colotomy is made in the transverse colon, this opening being more easily controlled and cleansed facilitates subsequent restoration and closing of the bowel. Also in the event of secondary operation for the repair of the rectum the pelvic colon can be mobilized and brought down to the injured part.

Bladder wounds are fortunately rare, for their mortality is very high. Extraperitoneal injury, indicated usually by hemorrhage into the bladder, may be treated by catheterization or by perineal section; intraperitoneal injury, however, the more serious of the two, demands immediate operation.

Of the solid viscera the liver is the most frequently involved, and is at the same time the viscus which most often recovers without operation. Operation is indicated where there is evidence of profuse hemorrhage, and generally consists of inspection, plugging and drainage.

Wounds of the spleen *per se* usually require splenectomy. They gener-

ally occur as complications of other lesions. This is also true in the rare instances of wounds of the pancreas. The prognosis of pancreatic injury is bad, hemorrhage is generally very severe, and treatment is mainly directed to controlling hemorrhage by suture or gauze packing and lumbar incision.

Post-operative treatment of the traumatic abdomen does not essentially differ from the regimen in use for other abdominal operations. In fact, this necessarily rapid and cursory survey seems to bear out the statement that there is little difference in civil and war surgery of the traumatic abdomen. The great advantage gained from war experiences is the removal of any hesitancy in exploring the abdomen, and with it the reduction of about ten per cent. in the mortality in this type of injury. This alone justifies the prevalent practice of early and thorough exploration and operation, although, if carried to its logical conclusion, it represents a certain risk of losing some cases that might have recovered without operation.

ACUTE PANCREATITIS*

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In the presence of an acute abdominal crisis the practitioner is likely to forget about a certain elongated gland situated in a deep recess behind the stomach as the probable cause of the sudden and dramatic syndrome he is called in to treat. It is because of the importance of this organ in upper abdominal disease that I venture once more to discuss the subject of acute pancreatitis.

It is, perhaps, no exaggeration to say that the condition is more often unrecognized than it is diagnosed before operation. There are a number of reasons why this is so. In the first place it is comparatively infrequent, but nevertheless more frequent than is generally supposed, and, as in other abdominal conditions, there is no one sign or symptom that can be said to be pathognomonic of the disorder; and most often the desperate condition of the patient makes operation imperative without the formality of a definite diagnosis. The latter, of course, applies particularly to the ultra-acute cases. It is in the less acute cases diagnosis is important, as we shall presently see. Another fact that interferes with a positive diagnosis is that acute pancreatitis is so frequently associated with other severe abdominal lesions, such as cholecystitis, perforating cholecystitis, perforating gastric or duodenal ulcer, appendicitis, etc. In fact, it is often mistaken for one or the other of these conditions; most cases, however, come to operation with a diagnosis of acute intestinal obstruction. Differentiation is usually possible only after a careful examination and a carefully taken history, and then only if the case is seen early, that is, several hours, or at most a day or two after onset. The confusion is also in some measure due to the fact that pain, without doubt the most conspicuous and persistent symptom, in acute pancreatitis may arise in various parts of the abdomen, although, as a rule, it originates deep in the epigastrium rather to the left, later radiating to the back, and is at once severe and overwhelming. It is, if possible, more agonizing than the pain of perforating viscus. Shock in the ultra-acute case may be so extreme that death ensues in a few hours. Shock is more prolonged in severe cases of acute pancreatitis than in ruptured viscera. The character of the pain differs from that of acute intestinal obstruction inasmuch as in the latter the onset is less severe and is at first intermittent, growing progressively worse in the course of a few hours. I may, however, remark that in the acute obstruction due to strangulated internal hernia and twists, the pain is intense and at first referred to the site of the initial pathology. With regard to the localization of the pain in acute pancreatitis,

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Desjardin has suggested a *pointe pancreatique* over the outlet of the duct of Wirsung, 5–7 cm. above a line connecting the umbilicus with the right axillary cavity, as of diagnostic value, but this has not been found a constant feature. The Mayo-Robson's point, about 10 cm. above the umbilicus, is more characteristic. Sometimes the pain localizes in the region of the appendix, and is then probably due to a distention of the inflamed peritoneum, as the result of the diffusion of the exudate in the region of the cæcum, such as often takes place in perforating gastric or duodenal ulcer. Or again, as the result of the inflammatory process and the action of the pancreatic juice, there is necrosis and sloughing of the tissues which find their way into the ileocæcal region and give rise to a tumor mass suggestive of appendicitis, as in the case reported by de Groot and also one in my experience. Operation in de Groot's case revealed a normal appendix; the abdominal cavity was filled with blood-stained exudate, and there was no trace of blood in the pancreas. Typical fat necrosis was found in the ascending colon and in the preperitoneal fat. A large stone was present in the gall-bladder. There had been a history of several attacks of severe epigastric pain radiating to the right, and a diagnosis of acute appendicitis had been made.

In my case the patient came to the hospital for the relief of a biliary fistula which had formed after a cholecystostomy (done elsewhere) one year previously. There was tenderness and marked rigidity in the region of the right iliac fossa. At operation the appendix was found to be normal. Operation consisted of cholecystectomy and appendectomy. The pancreas was enlarged throughout, especially its head. After operation bile continued to drain for several days, followed by a discharge of pus. The tenderness in the right iliac fossa persisted. A second operation four weeks later revealed an abscess, material from which contained fat necrosis. The patient died on the sixteenth day. At autopsy the pancreas was found completely necrosed.

Vomiting is a constant feature of acute pancreatitis and is frequent and persistent for at least twenty-four hours, when it may subside somewhat; except in the late stage, it is not fecal. Nausea and retching may continue; hiccough is a frequent symptom and is persistent and oft-repeated.

The accompanying constipation is not always complete. In this it differs from intestinal obstruction. Flatus is sometimes spontaneous or can be obtained, and stool, also, by enema.

There is absence of marked rigidity, which, on the other hand, is the most pronounced physical feature in ruptured viscera. Tenderness in the left costovertebral angle is of extreme importance from a diagnostic point of view, indicating, as it does, involvement of the central portion or body, and more especially the tail of the pancreas. Distention is not so marked as in other abdominal crises, and is limited at first to the upper portion of the abdomen; in fact, the small intestine has in some instances been found collapsed.

The pulse is usually quiet and slow at first, and gradually increases. Subnormal temperature accompanies the initial collapse, but rises moderately later on. The temperature range is low compared to that of a spreading peritonitis.

Cyanosis is often seen and appears as, what is considered by some, a characteristic dull yellow hue.

There is leucocytosis, and the polynuclear count is increased.

As to predisposing factors, obesity and alcoholism are sometimes mentioned. Age and sex do not seem to play a part in this respect, as the disease has been observed in young persons of both sexes as well as middle-aged and older ones. In the series of fifteen cases operated at the Lankenau Hospital, since 1913, the ages ranged from twenty-four to fifty-four. Some authorities, notably Körte, claim a preponderance of males in the proportion of two to one. This has not been my experience. In the above 15 cases there were 11 females. Linder[1] reports 76 per cent. females in 33 cases.

We may therefore say that a sudden acute abdominal seizure, pain overwhelming, in an apparently healthy, usually obese, individual, accompanied by incessant vomiting, upper abdominal distention, a transverse resistance not easily elicited, weak pulse, subnormal temperature, collapse, and sometimes cyanosis, should suggest acute pancreatitis. The previous history will usually reveal one or more, usually more, attacks of severe epigastric pain which have been regarded as gall-stone colic and have been treated as such. Not infrequently the first attack of this kind occurs during or soon after a pregnancy. That it may be due to a pancreatic lesion is well illustrated in Case II, cited below. Watts[2] reports 7 cases of acute pancreatitis, 2 of which occurred four and seven weeks respectively after a pregnancy.

There is, indeed, little doubt that in a large number of cases of gall-stone disease the pancreas has been involved, and it is because of this fact and because of the unfavorable prognosis presented by acute pancreatitis as such that I so strongly and continuously advocate early surgery for gall-stone disease, as well as for other chronic abdominal conditions. It is a well-established fact that the gall-bladder is the upper abdominal organ most frequently affected by infection. Owing to the anastomosing network of lymphatics in the retroperitoneal tissue which connects the gall-bladder and the pancreas, it is but natural that secondary infection of the pancreas may occur by this route. In like manner, not a few cases of gastric and duodenal ulcer and also colitis have come to be associated with disease of the pancreas. Here again the path of infection can be traced through the lymphatics leading from the colon through the transverse mesocolon to the pancreas. My experience with small circumscribed abscess of the pancreas in perforating appendicitis and, in another instance, of pancreatic abscess

[1] Jour. Amer. Med. Assoc., 1917, lxix.
[2] Ann. Surg., 1917, lxvii, 293.

and retroperitoneal diffusion of pus from infection of the left lower extremity would also seem to indicate the possibility of retroperitoneal infection of the pancreas from a distant focus by way of the ascending lymph channels.

Acute pancreatitis is essentially a surgical disease, and the importance of making a diagnosis in the less severely acute cases thus becomes apparent. For merely the relief of tension afforded by operation in these cases not only favorably affects the circulation, but in providing an outlet for the exudates inhibits the local destructive toxic process. The extensive study to which the pancreas and its secretion have been subjected during the past decade have taught us to regard with increasing respect and alarm the inherent noxious action of the powerful ferments of the pancreatic juice. The typical areas of fat necrosis, which furnish the most striking and reliable diagnostic sign to the surgeon, we now know to be due to the lipolytic action of lipase together with the trypsin of the pancreatic juice. As I have elsewhere pointed out,[3] the rôle of the proteolytic ferment, trypsin, in connection with acute pancreatitis has only recently been recognized. It is but natural that any inflammation which causes a diffusion of lipase must also carry with it the other ferments of the pancreatic secretion. Trypsin as a factor in this process has been overlooked because its action is not so greatly evident as is the fat necrosis due to the lipase, although it is possible that hemorrhage, so often noted in acute pancreatitis, may be traced to the digestive action of the trypsin on the vessel walls.

Trypsin is known to be one of the most powerful ferments elaborated within the body. In weakly alkaline solution it exerts a powerful action in splitting proteins into their lower constituent molecules. While in the intestinal canal this action is part of normal digestion and the end products are made available for absorption and for metabolism, when directed against the tissues this powerful agent is capable of doing much harm. In other words, trypsin is normally secreted in the pancreas as protrypsin and requires the activation of the so-called enterokinase of the duodenum to convert its latency into active energy. This is one of the reasons why normally the pancreas itself escapes self-destruction. But in the presence of abnormal conditions, trypsin is activated within the pancreas, its digestive and destructive action is readily seen on the tissue cells and vessel walls of the pancreas and surrounding structures, injury of which permits the escape of blood, with acute hemorrhagic pancreatitis as the result.

The destructive action of trypsin may by inference and demonstration be further seen in the toxæmia of acute intestinal obstruction, which has been shown (in experimental work) to contain a powerful toxin that proves fatal in exceedingly small doses.[4] This substance complies with the essential characteristics of a proteose, one of the earliest decomposition products of protein when acted on by trypsin. Furthermore, the resemblance of the

[3] Jour. Amer. Med. Assoc., August 11, 1917.

[4] Whipple, Stone and Bernheim: Jour. Exper. Med., 1914, xix, 166.

toxæmia of acute pancreatitis to that of intestinal obstruction has been remarked by Sweet.[5] It is not at all unlikely that the toxæmia of the two conditions is either identical or closely related, and is due to the toxic derivatives of the proteolytic action of trypsin. The practical value of these theories, if true, is self-evident.

The surgery of the pancreas must be directed to providing an escape for the highly toxic pancreatic fluid which has become activated as the result of infection or of trauma, or as the result of a chemically induced inflammation by the irritating action of the dammed back bile. In other words, the pancreas must be drained. We are not yet prepared to resect the pancreas, although experimental work, notably that of Sweet, has shown that at least two-thirds of the gland can be removed with a reasonable degree of safety, the only difficulty being one of technic. For the present, however, especially in the ultra-acute cases, we can do no more than by rapid section and drainage hope to save the life of the patient. But outside of these desperate cases the question arises whether to confine the work to the pancreas or to deal with associated lesions. In the severe cases I have no hesitancy in stating emphatically that our energies should be confined to the pancreatic lesion. Operation on the bile tract plays little if any rôle in these cases, and the time consumed only adds to the risk. In a recent series of fifteen cases (operated since 1913), draining the pancreas was the only procedure in three, all of whom recovered; in three others a cholecystostomy with drainage of the pancreas, two recovered and one died; in this fatal case the question arises—had operation upon the pancreas alone been done would recovery not have occurred? One case of pancreatostomy and cholecystectomy ended fatally. This is the case already referred to. In the remaining eight cases nothing was done to the pancreas, drainage of the gall-bladder in six gave five recoveries, and drainage of the common duct together with removal of the gall-bladder in two resulted in one recovery and one death.

The mortality in the series (4 deaths) equals 26.6 per cent., an encouraging improvement on the figures of a previous series of 22 cases which represented a mortality of 54 per cent. (Deaver and Ashhurst: Surgery of the Upper Abdomen, vol ii, p. 303; Philadelphia, 1914).

As to the time of operation: In the fulminating case the rapid progress from bad to worse may make immediate intervention necessary. I am not always in favor of operating in a state of profound shock. I cannot agree with Sweet who favors operating in profound shock, using saline and adrenalin infusions before, during and, if necessary, after operation. In certain cases I deem it wise to wait for a short time in order to give the patient a chance to rally and to wait for the peritoneal inflammation to localize. This, however, is a matter of judgment acquired only by extended experience. In the interim, the Murphy-Fowler-Ochsner method of treat-

[5]Sweet: Surgery of the Pancreas, 1916, Philadelphia.

ment is instituted. Severe shock may be combated by the administration of morphine, infusions of salt solution, or adrenalin and pituitrin, and thus the patient's condition brought as speedily as possible to a point where operation may be undertaken with a reasonable expectancy of a favorable outcome. Early operation is desirable, especially in the hope of preventing the extravasation of blood and ferments into the pancreas and the surrounding tissues. Since the pancreas is not provided with a capsule, the extravasated material readily finds its way into the surrounding parts. The presence of blood and fluid exudate in the pancreas requires incision and packing with gauze. The question of the extent of incision or scarification and puncture of the pancreas cannot be stated in any hard and fast rules, our experience being still somewhat limited. Too free and indiscriminate an incision presents the danger of free hemorrhage, difficult to control. Sacrification of the peritoneum over the gland should, however, be sufficient to allow gauze drainage to be brought into direct contact with the surface; this also opens up the retroperitoneal space and aids in preventing accumulation about the pancreas. A few blunt punctures of the pancreas are of service in providing free exit for the contained blood, lymph, and the obstructed secretion.

In operating on the pancreas we may choose one of two routes—the transperitoneal or the extraperitoneal through a loin incision. The latter allows approach to the pancreas, especially its tail, without entering the peritoneal cavity. While this may be of advantage it does not permit free exposure of the parts, so that radical surgery, should it be indicated, is not possible. It is, in fact, feasible only where the symptoms point to the localization of the inflammatory exudate or to the presence of pus in the loin.

The transperitoneal route is in order in a beginning pancreatitis when the localizing symptoms are all epigastric, when there is a palpable tumor or when the diagnosis is in doubt. This doubt is often cleared up by the presence of fat necrosis and typical odorless beef broth fluid in the peritoneal cavity. Once in the general peritoneal cavity the pancreas itself can be reached either through the gastrocolic omentum, through the lesser omentum, or through the transverse mesocolon. While presenting the disadvantage of the risk of infecting the general peritoneal cavity, the advantages of this approach are seen in the free exposure of the operative field, the opportunity for radical surgery, should this be desirable, and for establishing adequate drainage, a most important item whether the disease is in a suppurative or in a hemorrhagic state. In acute hemorrhagic pancreatitis, having approached the organ through the transperitoneal route, the only possible procedure is to apply tampons and drains freely to the organ itself, going either above or below the stomach according to circumstances. Both tubes and gauze drainage should be used and should be conducted to the surface through an enveloping sheet of rubber dam to lessen the chance of adhesions to the stomach and intestines. Any free fluid in the peritoneal cavity should, of course, be removed by gentle wiping; for this pancreatic

exudate itself contains sufficient toxic material to cause death. Drainage of the pelvic cavity is also indicated in these cases.

One of the most troublesome postoperative effects of drainage in acute pancreatitis is the formation of sinuses. The effect of the pancreatic ferments on the tissues can be noted in the intense irritation of the skin over which the discharge flows and in the sluggish formation of granulations continuously subjected to the severe erosive action of the pancreatic juice. The skin should, for this reason, always be protected by a bland ointment to prevent contact with the secretions, for after excoriation has once taken place it is practically impossible to get anything to stick to the moist surface. In order to limit the activity of the pancreas a strict antidiabetic diet, as suggested by Wohlgemuth, is advisable, and is found useful in promoting healing.

In conclusion, permit me to give two recent histories which will serve to illustrate some of the points contained in this discussion.

CASE I.—Female, fifty-four years old, married, admitted July 10, 1917, with a history of repeated attacks of severe abdominal pain requiring morphia for relief. The pain was generalized over the whole abdomen, but was most pronounced over both hypochondriac regions, extending to the back. Persistent vomiting accompanied the attacks. Never jaundiced. Had one such attack three weeks ago, and another the day before admission. Vomiting in the latter had ceased for several hours, but nausea persisted. Bowels moved day before admission. No cardiac, respiratory or nervous symptoms.

Past medical and social history otherwise negative.

Physical Examination.—Obese, middle-aged woman. No jaundice or adenopathy. Teeth fair. Throat congested; left tonsil inflamed and swollen, no exudate. Chest negative. Heart regular, slow, poor tonus. Blood-pressure 120–80.

Abdomen: Slight general distention; tenderness marked in upper abdomen equally on both sides, with rigidity partly voluntary. No masses palpable. Peristalsis subnormal. Temperature on admission 98°; pulse 56; respiration 24.

Tentative diagnosis, gall-bladder disease.

Operation (July 11, 1917).—Upper right rectus incision. Small amount of turbid fluid present in the peritoneal cavity, infiltrating the great omentum. Stomach found distended and pushed forward. A rent was made in the gastrocolic omentum, opening up the lesser peritoneal cavity, from which a turbid fluid escaped. The pancreas was found to be ruptured. One piece of gauze was packed into the pancreatic substance. A sheet of rubber dam was placed down to the pancreas and one piece of gauze within it. Another piece of gauze was packed outside the rubber dam. The gall-bladder was opened and a cholecystostomy performed. Wound closed to drainage. Dry dressing.

The patient had a prolonged convalescence with septic tempera-

ture for some time. Was discharged, August 29, 1917, with a clean granulating wound almost closed.

CASE II.—Woman, aged twenty-four, married. Admitted February 16, 1917, with severe pain and abdominal distention. Onset of pain four days ago. Began in left chest and later in epigastrium, radiating around both costal margins to both shoulders, and then spreading over entire abdomen which became very much distended. Persistent vomiting of bitter greenish material. Unable to retain any food. Bowels moved by purgative, distention subsided somewhat. Has a slight cold but no pain in chest on deep respiration.

Previous history negative. Never had a similar attack. Has a child three weeks old.

Physical Examination.—Well-nourished, rather stout young woman. Lips parched. Tongue partly coated and peeling. Teeth poor. Breath foul. Chest respirations rapid. Expansion shallow. Breath sounds harsh. Heart negative.

Abdomen: General abdominal distention. Voluntary rigidity; unable to make satisfactory examination. Temperature 98°; pulse 84; respiration 28.

Operation (February 19, 1917).—Peritoneum opened. Omentum protruded showing multiple areas of fat necrosis. Gall-bladder distended with stones and gall-bladder chronically inflamed. Omentum adherent around gall-bladder. Lesser peritoneal cavity opened through the gastrocolic omentum. Small cavity in the pancreas found filled with blood. Extensive fat necrosis present. Four pieces of gauze were packed in the cavity of the pancreas through the opening in the gastrocolic omentum. One cigarette drain was placed down to the pancreas. One piece of rubber dam was placed alongside of cigarette drain and two pieces of gauze superficially around the other drainage. Abdomen closed to drain. Dry dressing.

The patient made a good operative recovery, but continued to drain freely for several weeks. Convalescence interrupted by left pneumonia and acute tonsillitis. Finally a good recovery, and was discharged May 6, 1917.

THE INCIDENCE OF CALCULI IN THE GALL-BLADDER AS MET WITH IN 1600 NECROPSIES

By Louis J. Mitchell, M.D.
of Chicago, Ill.

While Naunyn points out that accurate statistics of the occurrence of gall-stones can only be based on data obtained post mortem, objection is often made to the usual necropsy statistics in that such examinations are generally carried out in elderly subjects, of ages at which cholelithiasis is to be expected. Also, that they are largely from hospitals frequented mainly by the working classes, in whom gall-stones are not so frequent as in the well-to-do. For this reason it is thought the following notes on the incidence in 1600 subjects of all ages will be of value. They are derived from a service as Coroner's Physician many years ago, and, as a rule, from individuals dying suddenly either from violence or disease, and not in hospitals or almshouses.

In the 1600 necropsies, calculi were found in 50 cadavers, or 3.1 per cent. (In addition, on one occasion, a stone was found in the common duct with the gall-bladder obliterated; and on another, one in the cystic duct.) This percentage is higher than in some similar collections, approximately the same as in others, and decidedly lower than in still others. However, the gall-bladder was opened in every instance, so there was no possibility of any concretion being overlooked.

Necropsies

	Total No.	With Calculi	Per cent.
Erlangen and Münich (Ritter)	19,974	1,652	7.8
Petrograd, Obouchow Hospital (Hesse)	17,402	378	2.17
Basle (Roth-Courvoisier)	16,025	1,714	10.7
London, Guy's Hospital (Ticehurst)	11,133	335	3.
Copenhagen (Poulsen)	9,172	347	3.8
Japan (Miyake)	8,406	257	3.05
Kiel (Peters)	5,962	161	2.7
London, St. George's Hospital (Rolleston)	4,616	268	5.8
Calcutta (Rogers)	4,544	233	5.37
Dresden (Fiedler)	4,300	270	6.3
London, London Hospital (Walton)	3,755	131	3.48
Sweden (Scheel)	2,753	406	15.
New York, Presbyterian Hospital (Herter), gall-bladder only	2,371	179	7.6
Göttingen (Hünerhoff)	1,951	85	4.4
Albany, Bender Laboratory (Stanton)	1,667	120	7.2
Baltimore, Johns Hopkins Hospital (Mosher)	1,655	115	6.94
Chicago (Mitchell), gall-bladder only	1,600	50	3.1
Manchester (Brockbank)	1,347	101	7.4

NECROPSIES

	Total No.	With Calculi	Per cent.
Strasburg (Schroeder)	1,150	141	1.2
Panama (Clark), negroes	1,088	24	2.2
Tomsk, Pathologic Institute (Hesse)	1,000	31	3.1
Panama (Clark), whites and half-breeds	404	12	3.
Toronto (Ryerson)	333	12	4.

OPERATIONS

London Hospital (Walton), 10 years	76,410	409	0.53
Mayo Clinic, uterine myomata (Mayo)	1,244	92	7.1
Ann Arbor, laparotomies (Peterson)	1,066	135	12.6
Laparotomies (Truesdale)	500	34	6.+

Sex.—In this series there were 1315 males and 285 females; and the number with calculi was 28 (2.1 per cent.) and 22 (2.7 per cent.) respectively.

Other series give the proportion of the sexes as follows:

	Total Necropsies	Per cent. Males	Per cent. Females
Petrograd	17,412	0.73	4.75
Basle	16,025	5.9	15.5
Japan	8,406	2.5	3.98
London	4,616	2.5	3.2
Calcutta	4,544	4.05	8.1
Dresden	4,300	3.9	9.6
Sweden		(sexes equal)	
New York	2,371	2.4	4.2
Manchester	1,667	4.	15.
Baltimore	1,655	5.49	9.37
Chicago	1,600	2.1	7.2
Strasburg	1,150	4.4	20.6

Age.—The distribution by ages is shown in the next table:

	MALES				FEMALES		
	Whites	Negroes	Chinese	With Calculi	Whites	Negroes	With Calculi
Up to 20	113	10		2	41	3	1
21 to 30	274	32		2	68	14	3
31 to 40	326	21	5	3	62	11	7
41 to 50	301	18		4	42	5	4
51 to 60	131	3		4	18	2	3
61 to 70	71	1		13	13	2	2
71 to 80	6			1	3		2
Over 80	3			1	1		
	1,225	85	5	28	248	37	22
Youngest subject with calculi—25					Youngest subject—20		
Oldest—84					Oldest—75		

Courvoisier also found the maximum from 60 to 70, and 22.2 per cent. of Rogers' cases were over 60.

This may be compared with the age-incidence in 1071 cases (Hubbard, Lichty, and 4 other authors).

Under 20	7
21 to 30	80
31 to 40	207
41 to 50	274
51 to 60	258
61 to 70	245
Total	1,071

Color.—No calculi were met with in the 5 bodies of Chinese males, nor in the 85 male negroes; these latter included 2 Beninese from the west coast of Africa. Of the 37 female negroes, gall-stones were found in two, aged thirty-one and forty-two respectively.

Mosher states at Johns Hopkins, gall-stones were present in 7.85 per cent. of the whites and 5.51 per cent. of the negroes. Clark, from experience in the Canal Zone, concludes the West Indian negro is more liable to calculi than the same race in temperate climates. In fifteen years Rodman never saw a case in Louisville, Ky., and only one in ten years at Philadelphia. Though he adds that a few were reported to him from the Pennsylvania Hospital, located near a large negro colony.

There seems to be but little on record as to the prevalence of biliary concretions in tropical climates. Hirsch asserts they are "decidedly less common than in higher latitudes." On the other hand, Castellani and Chalmers state they are "often met with," which they attribute to typhoid fever, though they may also arise from other causes. At Calcutta, Rogers believes biliary calculi are actually more common than in some European climates. Mohammedans are slightly less liable than Hindus, and Europeans considerably more so.

According to Robson and Cammidge, Morehead during many years' practice in India saw only 4 cases. Rufz did not meet with a single case in Martinique, and the same experience is reported by Borchgrevink from Madagascar. Pruner Bey states that in Egypt they are rather more common in Europeans and Turks than in natives and negroes, and Hartmann speaks of them as being very unusual in any class. Elliot Smith has recorded an example of gall-stone in a mummy of the New Empire.

As regards China, while urinary calculi are excessively abundant, Jefferys and Maxwell record but a single case (Shanghai) though they received reports from practically all parts of the country. They observe that Middle China, about Canton, *e.g.*, escapes.

Number of Calculi.—In 13 instances single stones were found; in 37 more than one, from 2 or 3 up to 632.

Association with Carcinoma.—Scheel found cancer of the gall-bladder in 5 of his 406 cases, and Hesse in 15 of his 378 cases. In 5 more, though

cancer was present, there were no gall-stones. Malignant disease was met with in 4.4 per cent. of the 1164 cases in Courvoisier's series. None of the gall-bladders in the present series showed any gross changes resembling cancer. This statement, of course, is of limited value, since the time concretions were present is not known.

In this connection the cause of death as established at the post-mortem examination is of interest:

	With Gall-Stones	Total Necropsies
Valvular heart disease (aortic, 9; mitral, 2)	11	58
Fatty degeneration, and other forms of myocardial disease	5	95
Pneumonia	8	95
Pulmonary tuberculosis	3	67
Chronic pleuritis	1	18
Cirrhosis of liver	1	6
Nephritis	2	39
Apoplexy	3	23
Alcoholism	3	141
Senility	1	2
Abortion	4	
Murder	2	
Suicide	3	
Accident	3	

In no instance was the cholelithiasis the direct cause of death.

Association with Valvular Disease of the Heart.—Brockbank in his experience at Manchester in 1347 necropsies found biliary calculi in 5.4 per cent. of the cases without cardiac disease, and 10.9 per cent. of those with such disease; and more with the mitral variety. (His figures are derived from the Infirmary.) In this series there is practically no difference between mitral and aortic disease.

	With Gall-Stones	Total Necropsies
Aortic disease	42	9
Mitral disease	11	2
Combined aortic and mitral disease	5	0

Rolleston found the percentage of gall-stones was "a little higher" in aortic than in mitral disease.

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KIDNEY-URETER ABNORMALITIES

By Thomas N. Hepburn, A.M., M.D., F.A.C.S.
of Hartford, Conn.

Congenital abnormalities of the kidney and ureter are now known to be very common, and, with the improved methods of diagnosis, they can generally be recognized before operation. In reporting cases of abnormalities it is regrettable that some of the reports in the literature are not as full as might be wished, inasmuch as it is difficult to tell whether the diagnoses were made before operation, at operation, or at autopsy, and we are told little of the post-operative history in some cases.

The first case I wish to report is one of *fused ureters*. I find, in a cursory review of the literature, only one like it reported. That case was reported by Braasch in Annals of Surgery, vol. lvi, p. 726.

Case I.—October 16, 1916. Female, aged thirty-one years; married; housewife; American. On personal ward service at the Hartford Hospital. Her family history was negative. Her past history was negative except for a severe attack of mitral insufficiency with broken compensation six years ago. She has had eight full-term pregnancies. Her present illness dates back four years, when pain in her right renal region began. This pain has continued off and on since, and two days ago became severe. Then for the first time she sent for a physician, who sent her to the Hartford Hospital. No dysuria.

Examination.—A well-nourished, vigorous-looking woman, evidently in pain and acutely ill. Her heart showed mitral insufficiency with compensation. In the region of the right kidney was a large tender tumor. The urine was very full of pus. Her temperature was 103.8 and her leucocytes were 24,200 (88–12). X-ray examination showed no shadow other than the indefinite outline of a large kidney. Cystoscopy showed a bladder wall almost normal. There were practically no signs of cystitis. The right ureteral os was slightly dilated, and ejaculations of very pussy urine could be seen easily. I attempted unsuccessfully to catheterize it, the catheter being stopped 3 cm. up. The left ureteral os could not be found after a thorough search. Realizing that it was essential to establish the presence of a normally functioning left kidney before removing the pyonephrotic right one, I injected intravenously 20 c.c. of a .4 per cent. solution of indigo carmine as an aid to locating the os of the left ureter. To my surprise it appeared promptly and in dense clear blue spurts from the right os. Then could be definitely seen alternating the ejaculations of dense pussy urine and the brilliant purple urine from the single right os.

Diagnosis.—Right pyonephrosis. Normal left kidney. Right and left ureters fused. I did not attempt to establish the point of fusion by the injection of thorium or any other fluid for a pyelogram, as

Braasch did in his case, because I feared forcing some of the infected urine up into the good kidney. The patient was in a very bad condition and required quick relief, rendering imperative early removal of the right kidney.

First Operation (October 17, 1916).—Under ether anæsthesia the right kidney was exposed and found to be so greatly infected that nephrectomy was desirable. My assistant was very dubious about the presence of a left kidney, so before starting the right nephrectomy, the left loin was opened and the presence of a normal left kidney demonstrated. The large pyonephrotic right kidney was then quickly removed. The ureter was carefully dissected down for 3 inches so as not to ligate below its fusion with the left side and tied with No. 2 chromic catgut.

Post-operative History.—She made a very quick recovery, but the wound continued to drain pus, and after one month urinary drainage began. This continued in spite of the improvement in her general con-

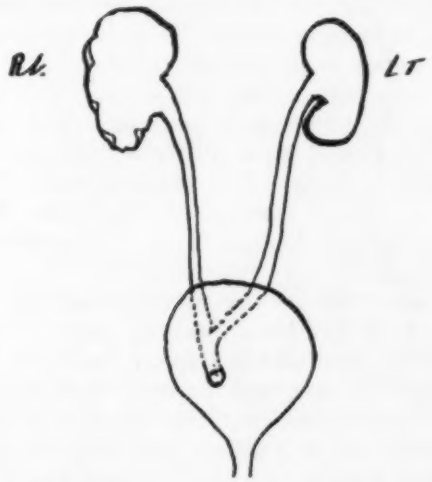

FIG. 1.—Diagram of a case of fused ureters.

dition. I had her return to the hospital and again cystoscoped her. Chromoscopy with indigo carmine revealed the same dense ejaculations of purple urine from the single ureteral os on the right side. It also appeared in the urine from the right lumbar wound. As there was still pus from the right ureter I made no attempt at pyelography to establish the point of fusion. This question it seemed to me safer to establish by an extensive open dissection along the course of the old right ureter before resecting it.

Second Operation.—A long incision was made along the right border of the abdomen and the right ureter was exposed retroperitoneally from its renal end well down into the pelvis, but no sign of the fusion could be found. The incision was such that I could not see well at the bladder end, and I feared injuring any tissue that might contain the left ureter. Therefore I made a midline suprapubic incision, and peeled the peritoneum off the bladder, thus exposing the bladder end of the ureter more easily. The fusion with the left ureter was then found

just outside of the bladder wall as shown in the diagram (Fig. 1). The right ureter was ligated close to the fusion and the wounds closed. The woman made a quick recovery, leaving the hospital in two weeks. She has had no urinary difficulty since, although she has been in the hospital recently with a recurrence of her heart trouble.

The second case I wish to place on record is one of bilateral duplication of kidneys, pelves and ureters.

CASE II.—Mrs. Mary W., aged forty-five years, entered the Hartford Hospital February 23, 1918. Her family history and past history revealed nothing of note.

Present illness dates back "many years," as pain in her right side, which her various doctors called liver trouble, in spite of urinary frequency and dysuria of four years' duration. The pain has been getting worse lately, and beginning one month ago she began to notice a swelling in her right hypochondrium. The doctor sending her into the hospital took the tumor to be a gall-bladder.

Examination.—Shows a rather thin woman with an easily palpable tumor in the upper right abdominal quadrant which extends back over the right renal fossa, and anteriorly one inch beyond the midline. The urine is loaded with pus. The temperature and leucocytes show moderate elevation. X-ray shows no shadow other than the indefinite outline of a large right abdominal tumor. Cystoscopy shows a mild general chronic cystitis.

On the right side there are two ureteral openings 2 cm. apart, one above the other. From the lower opening pussy urine can be seen to come. A No. 6 F. ureteral leaded catheter was easily admitted 20 cm. up each of the right ureters, and the cystoscope was withdrawn and threaded with two more catheters. Two ureteral openings were found on the left side, and were each catheterized with No. 6 F. leaded catheters. The catheters were marked right, upper and lower; left, upper and lower.

The right upper catheter drained freely a very pussy urine which was sent to the laboratory, where the pathologist found pus-cells and a thick growth of colon bacillus.

The right lower catheter drained freely clear, normal looking urine which was collected in a sterile test-tube and sent to the laboratory, where the pathologist found it to be normal.

The left upper catheter drained normal appearing urine which was pronounced negative in the laboratory.

The left lower catheter drained normal urine, also pronounced negative in the laboratory. Differential renal function was done by the injection intravenously of a .6 of a milligramme of phenolsulphonephthalein which was excreted as follows: From the right upper catheter not at all; right lower catheter in 6 minutes and in 15 minutes 5 per cent.; left upper catheter in 6 minutes and in 15 minutes 5 per cent.; left lower catheter in 6 minutes and in 15 minutes 5 per cent. There was no bladder leakage.

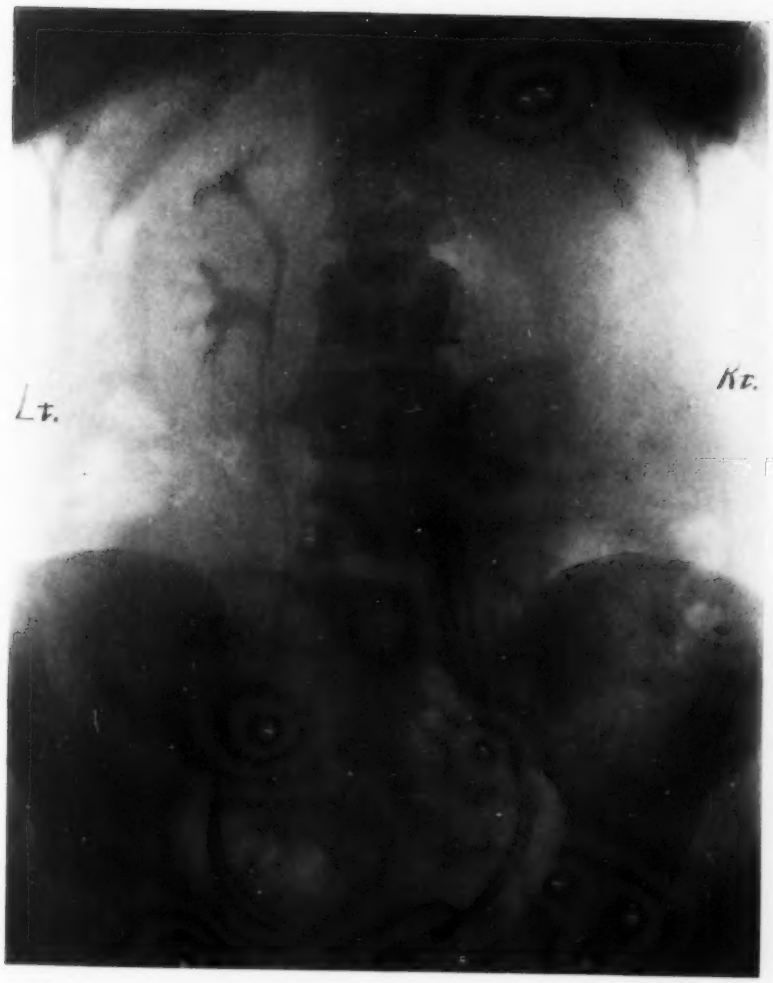

FIG. 2.—X-ray of leaded catheters and 15 per cent. thorium injections, showing bilateral duplication of kidneys, pelves and ureters.

Pyelography.—Fifteen per cent. thorium was inserted into each catheter by gravity and an X-ray picture taken which is shown in Fig. 2. This demonstrated a duplication of ureters and pelves on each side. The picture on the right side is not so clear because of the large pyohydronephrotic upper kidney concealing the normal pelvic outline of the lower right kidney (see Fig. 2).

Diagnosis.—Bilateral double kidneys, pelves and ureters, one of the right kidneys being pyonephrotic.

Operation (Dr. George N. Bell) (February 26, 1918).—Under ether anæsthesia the right kidneys were exposed and the large upper pole of the tumor so enveloped the lower normal kidney that it seemed dangerous to try to separate them. Therefore, the pyonephrotic upper kidney was removed with the lower normal kidney *en masse*. The wound was closed without drainage and the patient made a quick recovery.

The pathological report by Dr. Henry C. Russ was as follows:

> Macroscopically the specimen showed a dark reddish-brown kidney 6½ cm. long and normal in shape, with a ureter 3 mm. in diameter. Above and separate from this is the dilated shell of anothr kidney with a ureter dilated to 10 mm. in diameter. The calyces of this upper kidney are much dilated and communicate with a much-enlarged pelvis. The cortex is very thin, the pyramids having disappeared. There is a separate blood supply to each kidney.

This case is the only one I can find with proven bilateral duplication of kidneys, pelves and ureters. Braasch, in the same article referred to above, shows a diagram of a case apparently almost complete, but there is a connection between the calyces on one side. There is no doubt but that the operation in the case here reported should ideally have been the removal of the infected right kidney alone, leaving the normal one—as Young, Mayo and others have done—but it seemed dangerous at the time to attempt it.

DIVERTICULA OF THE BLADDER*

By E. S. Judd, M.D.
of Rochester, Minn.

The increasing frequency with which we have encountered diverticula of the bladder in the past few years has led me to review the cases that have been treated at the Mayo Clinic. Presumably this condition does not occur more frequently now than formerly; though with a somewhat better understanding of the surgery of the bladder in general, and with the great advance in methods of examining all patients with bladder trouble, many more are being presented for surgical treatment.

ETIOLOGY AND PATHOLOGY.

The question as to whether or not these diverticula, as well as those occurring in other parts of the body, are congenital or acquired, has been widely discussed, and many convincing articles have been published supporting each contention. Undoubtedly diverticula of the bladder may be congenital, as instances have been reported in infants and small children, and it would certainly seem that in most of such cases there must have been some congenital defect in the bladder as a primary etiologic factor. If the condition were always due to obstruction, it would probably occur more often in cases in which the stream of urine is obstructed. It has been suggested that the weak points in the wall of the bladder may be at the site of one of the embryonic buds. While it seems possible that a diverticulum might occur at one of these points, and that this embryonic weakening might be the factor in certain cases, on the other hand, my observation leads me to believe that the point of dereliction is not constant enough to indicate that the majority originate from these buds. In most of our cases the opening of the diverticulum was not far from one of the ureteral meatuses, but the relationship to the meatus was not at all constant, so that in some cases, the diverticulum opened into the bladder in front of the meatus of the ureter, in others, well above it or posterior to it, and in some cases in the base of the bladder posterior to the trigone. It is certain, however, that the greater number of the diverticula do have a proximity to the ureter. The diverticulum that occurs in the dome is rarely seen, and apparently is an entirely different type than the diverticulum under discussion.

The close relationship of the diverticulum to the ureter may mean that the diverticulum, especially if it is of considerable size, will interfere with the ureter. Several cases have been reported in which a hydronephrosis and a pyonephrosis have developed, apparently due to this interference with and pressure on the ureter. Cabot reports an interesting case in which bilateral

* Read before the American Surgical Association, June 7, 1918.

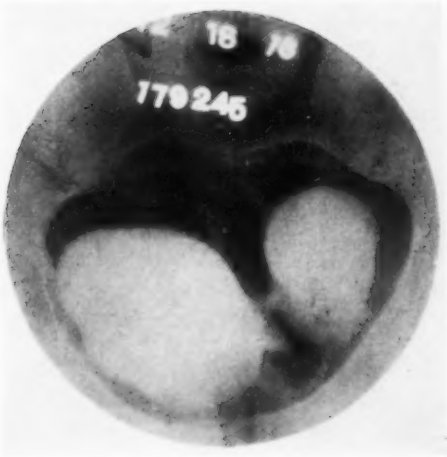

FIG. 1.—(179245) Cystogram of a diverticulum from the left base of the bladder opening 2 cm. posteriorly and to the left of the left meatus. Resection of the diverticulum.

FIG. 2.—(206754) Cystogram of a diverticulum from the right base of the bladder, opening 2 cm. from the right meatus. Resection of the diverticulum.

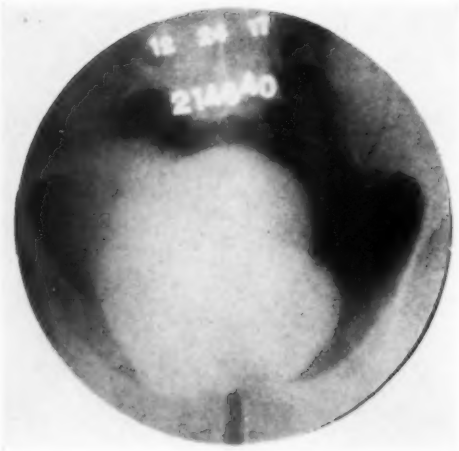

FIG. 3.—(214640) Cystogram of a diverticulum of the right wall of the bladder opening about 3 cm. posteriorly and to the right of the right meatus. Resection of the diverticulum.

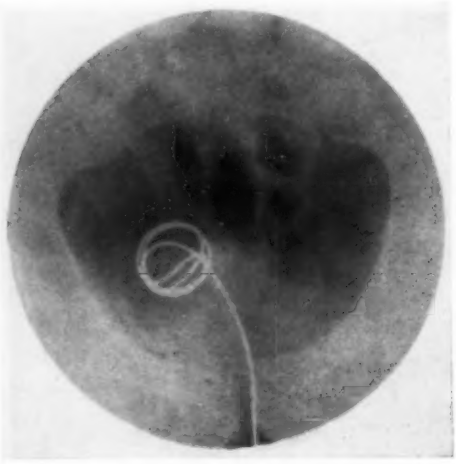

FIG. 4.—(206754) Stylet coiled in the diverticulum from the right base of the bladder. Opening 2 cm. from the right meatus. Resection of diverticulum.

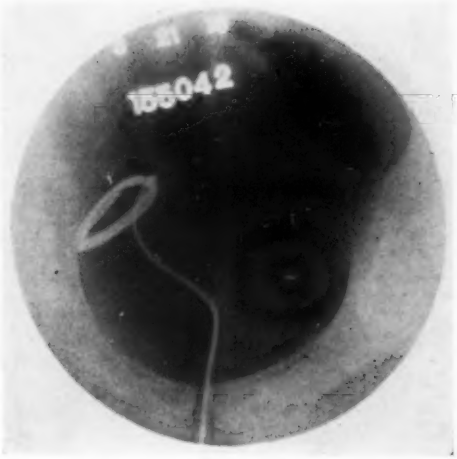

FIG. 5.—(155042) Stylet coiled in the diverticulum of the right base of the bladder. Opening 3 cm. from the right meatus. Resection of the diverticulum.

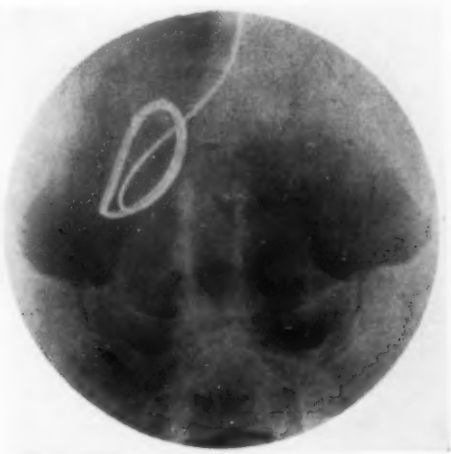

FIG. 6.—(224370) Stylet coiled in the diverticulum from the left base of the bladder. Opening 2 cm. posterior and to the left of the left meatus. Resection of the diverticulum and prostatectomy.

FIG. 7.—(226631) Diverticulum.

FIG. 8.—Same as Fig. 7. Low power section through the entire thickness of a large diverticulum, showing the mucous membrane.

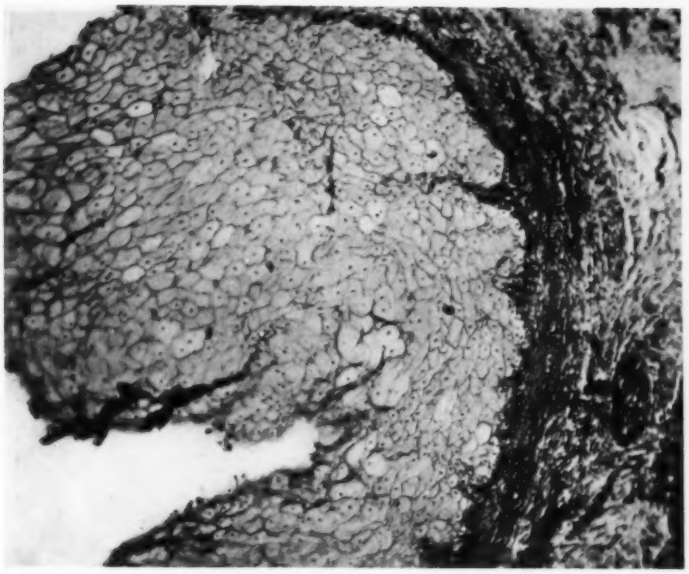

FIG. 9.—Same as Figs. 7 and 8. High power showing mucous membrane and strand of smooth muscle of a large diverticulum.

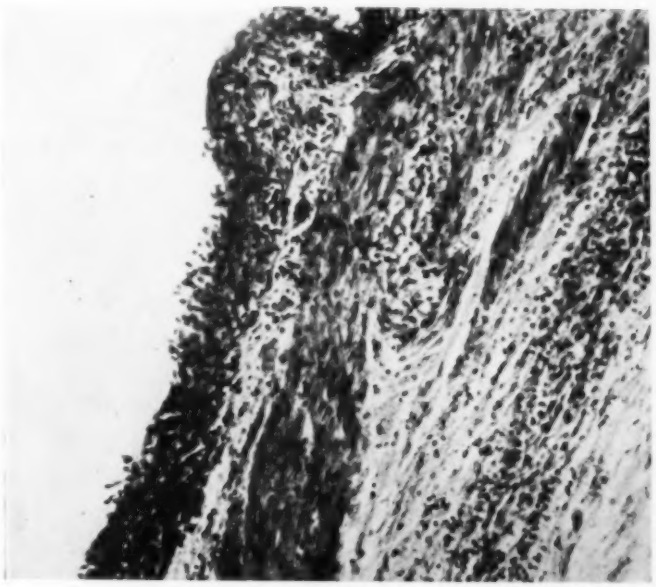

FIG. 10.—Same as Figs. 7, 8 and 9. Different area from Fig. 9. Showing scanty mucous membrane and strands of smooth muscle.

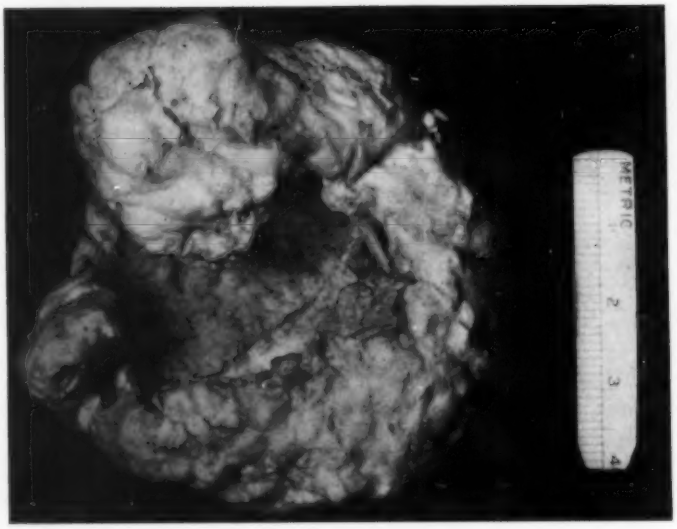

FIG. 11.—(49150) Diverticulum.

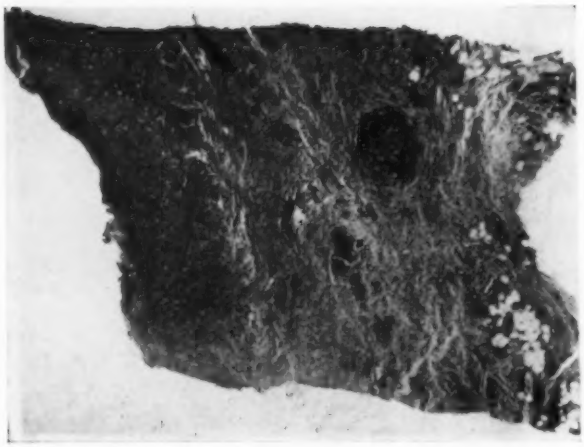

FIG. 12.—Same as Fig. 11. Low power, showing smooth muscle in fat. The mucous membrane is absent.

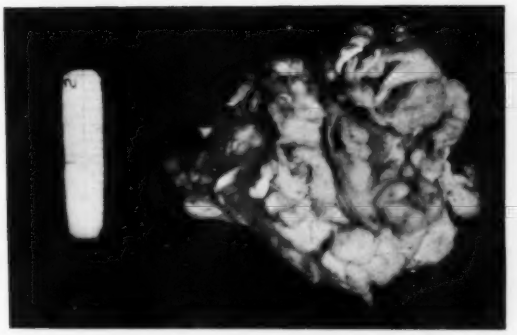

FIG. 13.—(206754) Gross photograph of diverticulum.

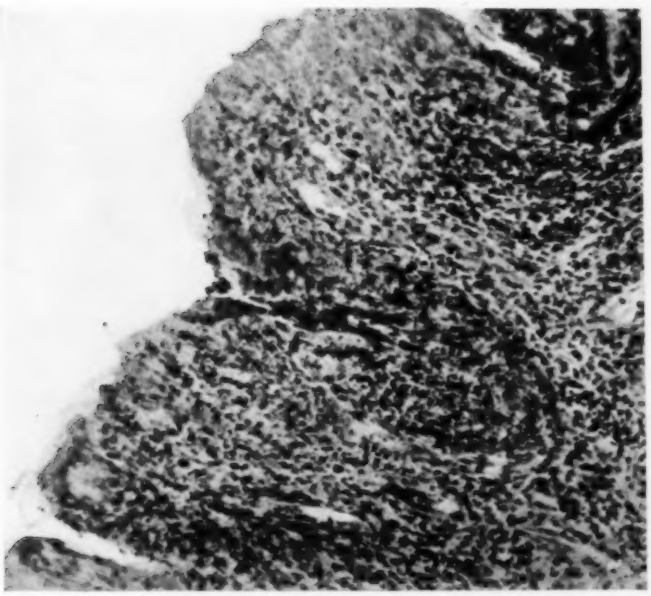

FIG. 14.—Same as Fig. 13. High power showing diverticulum. Mucous membrane with absence of muscle.

diverticula were interfering with both ureters. In our series an instance of this kind has not been observed, though in several instances we have been able to demonstrate that the ureteral meatus was just at the border of the opening of the diverticulum, and that in reality the ureter did open into the diverticulum. In one case the ureter emptied into the sac of the diverticulum, and it was necessary to divide the ureter and reimplant it into the new opening in the bladder. In several other cases in which the ureteral opening was marginal the adjoining mucous membrane was turned into the bladder closure, the meatus being preserved. It seems advisable to employ this method whenever it can be done. While a marked trabeculation of the bladder is often seen in cases of diverticula, at the same time it is not at all likely that the trabeculæ will ever become diverticula. Diverticula are true pouches, and in a bladder in which they exist there is always residual urine and other evidence of an incapable bladder. It is because of this that the trabeculæ form, just as they often do in cases in which the inability to empty the bladder is due to the obstructing prostate. When the difficulty is overcome by removing the diverticula, the trabeculæ disappear, as in prostate cases when obstruction is removed (Figs. 1–6).

CLASSIFICATION OF DIVERTICULA.

Diverticula have been classified as congenital and acquired. The congenital type was formerly thought to be those in which all coats of the wall of the bladder were involved in the diverticulum; the acquired type had a sac composed of mucous membrane only (Figs. 7–14). This classification, made by Englisch some time ago, would not, I think, hold according to most observers at the present time. It seems to be the consensus of opinion that a congenital deformity, or lack of development, is a factor in all of these cases. However, there seem to be two distinct types, one in which the diverticulum is associated with an enlargement of the prostate, and which has led some observers to believe that it is the result of the obstruction from the prostate, and the other type occurring in much younger men, in which there is no evidence of obstruction from any cause. The latter patients will frequently have more residual urine than those with an enlarged prostate and a diverticulum. In either of the two types, the diverticula may be multiple, though usually there is a large sac and one or more small ones.

Many cases have been cited to show that obstruction is not a factor in the causation of the condition. It has been demonstrated repeatedly that in case there is an obstructing enlargement in the prostate associated with diverticulum of the bladder, that the removal of the obstruction will not relieve the situation, and, furthermore, that the removal of the prostate and diverticulum will completely relieve all symptoms. I wish to emphasize this point particularly because I believe that many of the patients with prostatic trouble, who continue to have the so-called cystitis and residual urine after the obstruction has been removed, are, in reality, suffering from

diverticula, and that if a careful examination is made for a diverticulum at the time of the prostatectomy in such cases this error will be avoided. I feel certain that we have overlooked a number of diverticula among the prostatic patients, and that many are now receiving irrigations of the bladder, and catheterizations under the assumption that the symptoms are produced by cystitis, when in reality they are caused by the diverticula.

Whether the sac is composed of all the coats of the bladder, or whether it is composed of the mucous membrane alone, does not seem to draw a line between the etiology of the congenital and acquired types in these cases. There must be some congenital defect which will allow these sacs to develop, though their development may be aided and increased by an obstruction to the urinary outflow. In the young man with this condition, the bladder is usually large, but the wall is not particularly thick, and may appear quite normal. In the type occurring in older men, especially with prostatic trouble, the wall of the bladder is very thick from hypertrophy. In such cases, the sac is adherent and firmly attached to the side of, or beneath, the thick bladder, and there will frequently be much pericystitis and evidence of old and recent infection, without perforation. This usually exists in the cases in which the sac lies between the bladder and the rectum. In young men, the sac is thin, and is not firmly attached in the surrounding tissues, so that it is readily separated with very little dissection. Stagnation in the dependent sac favors infection, which results in diverticulitis and consequent cystitis. It has been our experience that in the infected case, apparently the greatest degree of infection is in the sac, though there is all the evidence of infection in the bladder as well. It is not unusual, in dilating the orifice of the diverticulum, to see thick pus escaping into the bladder, giving the appearance of opening an abscess under tension. Pericystitis and diverticulitis are always present to some degree in the case of the thick-walled sac. Calculi are often found in the sac, as was the case in four of our patients. In one of our cases, previously reported by Martin, a dumb-bell shaped stone, partly in the bladder and partly in the sac, was found. There was carcinoma in the sac in one of our cases, and carcinoma and stone in another.

CLINICAL FEATURES.

Diverticulum of the bladder occurs almost exclusively in the male; very few cases have been reported in the female. The characteristic feature of the clinical syndrome is a feeling that the bladder is not emptying. This comes on almost immediately after voiding, with the ability to repeat the act of voiding and the second time to pass a considerable amount of urine. Urination may be painful, particularly if the diverticulum is large. The sac may be palpated in some cases, especially through the rectum. Frequency and burning with difficulty of urination were present in most of our cases. Such symptoms always occur in cases after infection has taken place. Patients with diverticula have all the features of marked cystitis, and often

are treated over long periods for this condition. It is almost a pathognomonic sign of diverticulum to have a considerable amount of urine, thick with pus, escape from the catheter just at the time the bladder was supposed to be entirely clean. The urine in these cases is very foul, and on opening the bladder to perform a prostatectomy or drainage operation, should this foul urine be detected, a diverticulum should be suspected and looked for. In the long-standing case, evidence of a kidney infection, and insufficient renal function, becomes marked. A low percentage of phenolsulphonaphthalein return is not a definite contra-indication to surgical treatment in all of these cases; many of the patients do well in spite of this condition.

DIAGNOSIS.

While the diagnosis is suggested by the clinical features, the accurate determination of the condition rests with the cystoscopic examination, and the employment of the leaded catheter and X-ray, or by the making of a cystogram which is of great value in any doubtful case. The cystoscope will usually reveal the condition, though in the case of an enlarged prostate, or in very marked cystitis when the mucosa of the bladder is greatly congested and distorted, it may be impossible to see the opening through the cystoscope, and a cystogram should then be made. In other instances the opening of the diverticulum into the bladder is very small and difficult to see, but the colloidal silver solution will readily pass into it and the diverticulum can be seen when the röntgenogram is made. In any very marked case of cystitis in which the bladder is to be drained, a diverticulum should be searched for, even if these methods of examination fail to show one, as it is possible that the opening might be closed and the diverticulum not recognized at the time of the examination. In view of the fact that I have had a great deal of difficulty in making a diagnosis in some of these cases, particularly in those in which there was an obstructing enlargement of the prostate, it seems well to emphasize the necessity of a careful exploration of the bladder at the time of performing the prostatectomy in cases showing marked cystitis and infection at the time of the examination. A diverticulum should be suspected in the patient who has had a prostatectomy and still has a considerable amount of residual urine, particularly if there is much evidence of infection which does not respond to the ordinary treatment.

The present report is based on a group of 44 patients, operated on between February, 1908, and March, 1918. All of the patients were males, varying in age from eighteen to seventy-three years. Twelve gave a history of gonorrhœal infection, and 3 of the 12 had been treated for stricture of the urethra. There is no evidence to show that the infections or strictures were in any way responsible for or had anything whatever to do with the formation of the diverticula. Six of the 44 patients had been operated on previously for these symptoms without relief. Eight of the patients gave a history of some form of trauma, which might have been a factor to consider in the etiology, but the association was too remote to prove that

the trauma had anything to do with the weakening of the wall of the bladder, or in any way to have been a cause of the diverticula. We believe the trauma was merely incidental. Seventeen of the patients also had an enlargement of the prostate, and the remaining 31 had cystitis, graded at least three on a scale of 4. There was stone in the bladder in 6 of the patients, and carcinoma in 4; in one the carcinoma originated within the diverticulum. At operation the opening of the diverticulum was found in the floor of the bladder, or on one or the other of the lateral walls not far from the ureteral opening in 39 of the 44 patients, which shows that a large percentage of such diverticula originate in one of these regions. The greatest number, 19, were found near the base of the bladder on the right wall. Bladder trabeculation, 3 on a scale of 4, was noted in 38 of the 44 patients.

TREATMENT.

In reviewing the literature, and from our own records, it stands out clearly that palliative treatment and any other form of treatment other than excision of the diverticular sac, has not given good results. A mortality as high as 83.1 per cent. has been reported in cases in which there was a diverticulitis at the time of the operation. This percentage has been very greatly reduced. In the young man without infection, the results are uniformly good, though complete recovery may be slow. In some of our cases the wound was slow in healing, and in others several ounces of residual urine persisted for a number of weeks, though eventually it almost entirely cleared up. Something can be accomplished by preliminary washings of the bladder, and by employing methods to stimulate renal function in cases in which it seems necessary. Those who have had the most experience with these cases seem to be unanimous in the feeling that the proper treatment for any of these diverticula is complete excision of the sac, and that any treatment less radical will not be satisfactory. Our experience bears this out. Intravesical treatment, as can be readily seen, is of no avail except as a palliative when operation is contra-indicated, or preliminary to operation. Drainage of the bladder, even as a preliminary step, will seldom help enough to warrant its being done. We have drained a number of times in these cases, both at the time of the prostatectomy and when the diverticulum was the only lesion. I now believe that it is far better, under ordinary circumstances, to remove the diverticulum at the same time. Suprapubic drainage of the bladder, even when the drainage tube extends into the diverticulum and is left there for a long time, will not help permanently. So far as I am aware, the less radical operations, such as enlarging the opening of the diverticulum and doing a plastic operation on the opening, and of anastomosing the diverticulum to the bladder, are not satisfactory. Therefore the treatment resolves itself into the excision of the diverticulum as soon as the patient's general and local condition has been improved as much as possible.

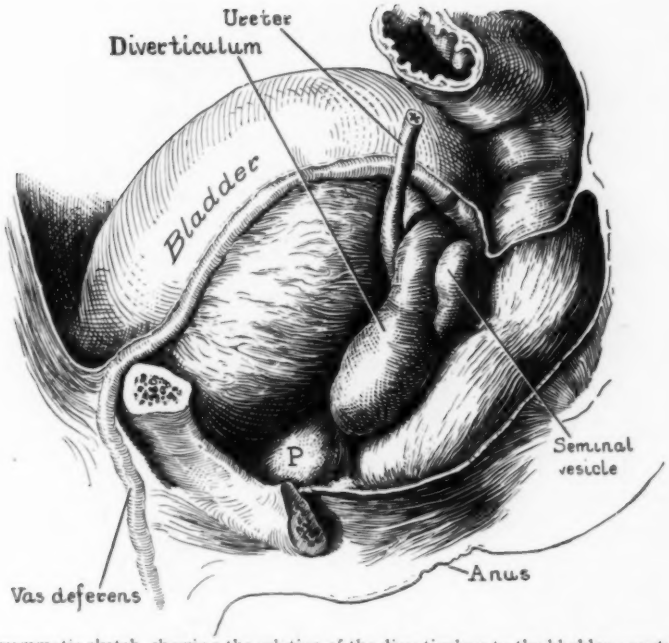

FIG. 15.—Diagrammatic sketch, showing the relation of the diverticulum to the bladder, prostate, rectum, seminal vesicle and ureter.

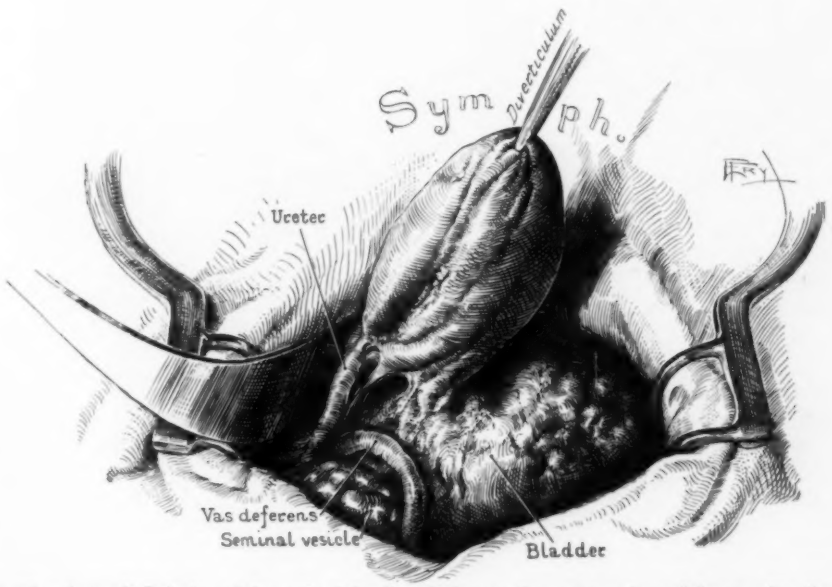

FIG. 16.—(215976) Relation of the neck of the diverticulum to the ureter and vas deferens, after the sac of the diverticulum has been dissected out from beneath the bladder.

FIG. 17.—(215976) The situation of the diverticular sac on the left posterolateral wall and at the base of the bladder. The ureter enters the sac instead of the bladder. The cavity of the sac is approximately half the size of the bladder cavity.

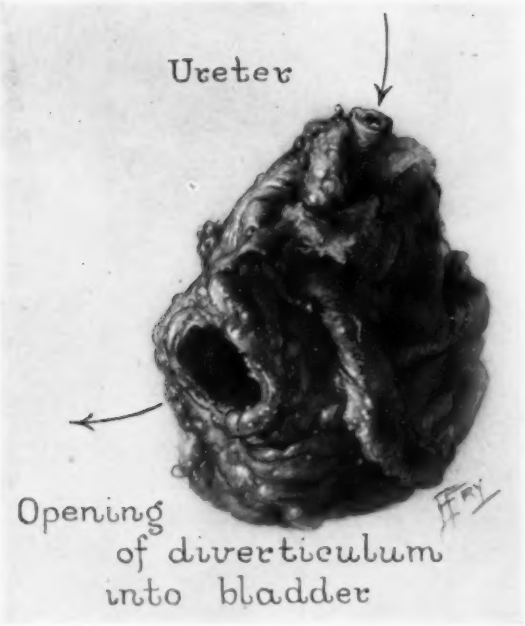

FIG. 18.—Diverticular sac and its opening, which communicates with the bladder. Note the ureter entering the sac.

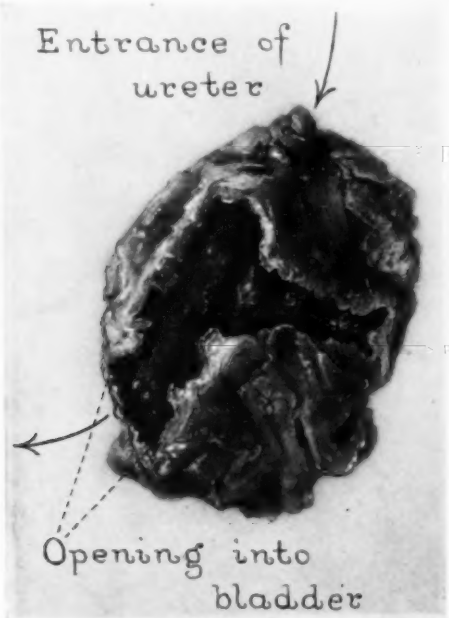

FIG. 19.—(215976) The diverticulum after it has been cut in half. Note the communication opening into the bladder and the entrance of the ureter into the diverticulum.

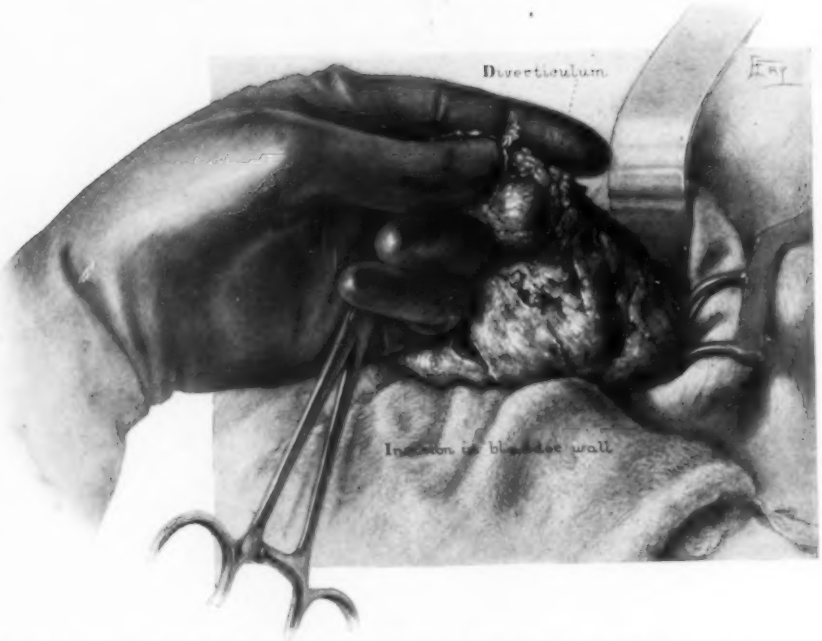

FIG. 20.—Finger passing through the incision in the dome of the bladder into the neck and cavity of diverticulum. The diverticulum being lifted out of the surrounding prevesical tissues.

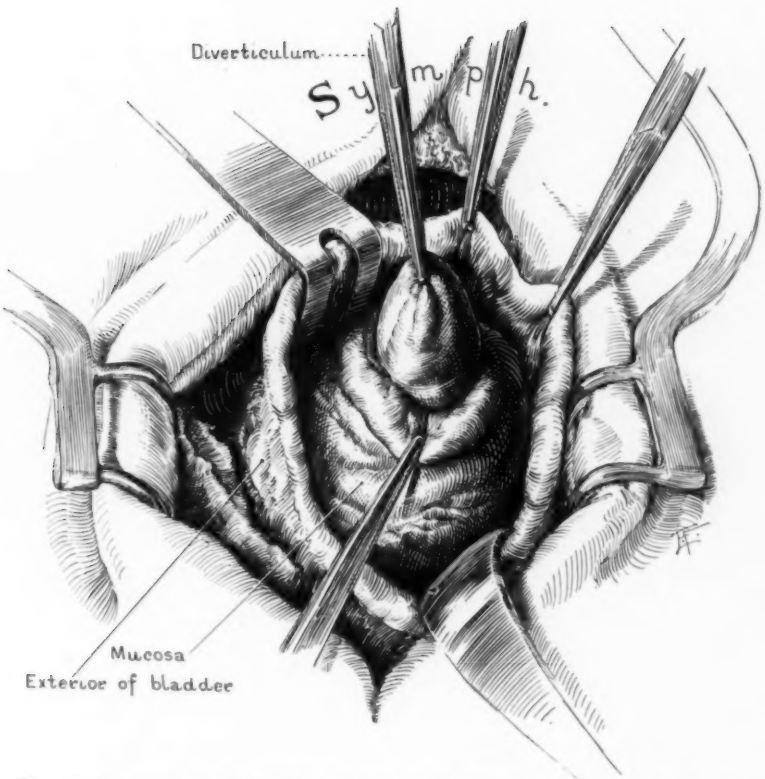

FIG. 21.—Transvesical operation for diverticulum of the bladder. The diverticulum is not adherent, and is tracted into the bladder by hemostats.

The operation consists in first making a fairly good-sized opening into the bladder through the prevesical space, and locating the opening of the diverticulum, after all the pus and infected mucus has been cleared away. The prevesical tissue should be protected against infection in every way possible. Ingenious methods have been devised for filling the diverticulum with an air-filled rubber bag (Lerche) and also for filling the sac with gauze (Lower) which is packed into the sac beforehand, to facilitate its removal. Such devices seem to help considerably. Whenever possible I prefer to pass one or two fingers into the diverticulum, and then make the dissection through the prevesical tissues down on to the sac, which is also being lifted out by the fingers within it. This method is not new; it can be employed in almost all cases, and is especially helpful when the sac is firmly attached to the surrounding tissues. If the sac lies high up and is covered by peritoneum, it may be best to open the peritoneum, though, as a rule, this is not necessary. After the sac has been completely freed from the surrounding fatty tissue, the neck is severed, the opening in the bladder is closed, and a drain is placed in the prevesical space which the sac occupied. The suprapubic opening in the bladder is closed, with the exception of the place for the drainage tube. The difficulties of the operation lie in separating the sac from the surrounding tissue, particularly if the sac is thick-walled, and if there is a great deal of old infection and scar tissue. The vas deferens and the ureter, both of which will come into view in many of the dissections, should always be avoided (Figs. 15 and 16). Occasionally it will be necessary to divide the ureter and reimplant it in a new area in the bladder, as I did in one of our cases (Figs. 17–19, Case 215,976). If there is an enlargement in the prostate, it should be removed at the same time (Figs. 20 and 21).

In this series of 44 patients, so far as we have been able to determine, all but ten are living. Two of the patients died within a few days after a drainage operation; both of these men had septic kidneys and drainage was of no avail. The other deaths occurred after the patients had been up and around for some time, and in most instances after they had gone home. The general and functional results in the remaining 34 patients have been uniformly good. The functional result, insofar as emptying the bladder is concerned, may be slow to adjust itself, though eventually it will be practically perfect.

Summarizing, briefly, it may be said, that diverticulum of the bladder is much more common than has been realized, and that the condition is perfectly amenable to surgical treatment.

FORTY-FOUR PATIENTS OPERATED ON FROM FEBRUARY, 1908, TO MARCH, 1918.
YOUNGEST, 18 YEARS; OLDEST, 73 YEARS; AVERAGE AGE, 52 YEARS.

	Cases
History of venereal infection	12
Urethral stricture in 3 (sound passed in 1, stricture cut in 2)	

	Cases
Previous operation on the bladder (elsewhere)	5
Previous perineal prostatectomy (here)	1
Symptoms dating from previous trauma	8
Enuresis since childhood	2
FIRST SYMPTOMS NOTED	
Hæmaturia	8
Difficulty in urinating	15
Frequency	21
SYMPTOMS	
Repeated urination	5
Hæmaturia	14
Pyuria	17
Burning on urination	26
Frequency	35
Difficulty in urinating (catheter used in 9)	24
Loss of weight noted	18
Average loss of weight, 15 pounds.	
Cystoscopic examination in	35
Hypertrophied prostate found in	17
Cystitis (average 3)	31
Bladder stone	6
Stone and carcinoma	2
Carcinoma (carcinoma in diverticulum in 1)	2
Cystoscopic localization of the diverticulum	35
Dome of bladder	3
Left wall and base	11
Right wall and base	12
Base	3
Multiple diverticula of base	6
URINALYSIS	
Pyuria	25
Hæmaturia and pyuria	17
Location of the diverticulum at operation	45
Right wall and base (10 near right ureter)	19
Left wall and base (6 near left ureter)	11
Left ureter in diverticulum	1
Floor and base	11
Dome	3
Bladder trabeculation, average 3	38
Bladder stones	7
Carcinoma	3
Carcinoma and stone	2
Hypertrophy of the prostate	18
Stones in the diverticulum	4
Carcinoma in the diverticlum	1
Carcinoma and stones in the diverticulum	1
TYPE OF OPERATION	
Intraperitoneal resection of the diverticulum	2
Extraperitoneal resection of the diverticulum	16
Extraperitoneal resection of the diverticulum and prostatectomy	7

	Cases
Extraperitoneal resection of the diverticulum, prostatectomy and removal of stones	1
Extraperitoneal resection of the bladder for cancer, prostatectomy and resection of the diverticulum	1
Extraperitoneal resection of the diverticulum and transplantation of the ureter	1
Drainage of the bladder and prostatectomy	5
Drainage of the bladder and removal of stones	6
Enlarging the opening of the diverticulum and drainage of the bladder	4
Separation of septum between bladder and urethra	1

DEATHS REPORTED IN THE FORTY-FOUR CASES, 10

Type of Operation	Length of Life	Cause of Death
Drainage of bladder	2 days	Pyelonephritis
Drainage of bladder	4 days	Acute septic nephritis.
Drainage of bladder and prostatectomy	25 days	Bilateral pneumonia
Extraperitoneal resection of diverticulum	28 days	Pulmonary embolus
Extraperitoneal resection of diverticulum	1 month	Pyelonephritis
Drainage of the bladder	2 months	Pyelonephritis
Drainage of bladder and removal of stone (carcinoma in the diverticulum)	2½ months	Pyelonephritis and perivesical abscesses
Enlargement of opening in diverticulum	9 months	Not known
Extraperitoneal resection of the diverticulum containing carcinoma	12 months	Not known
Drainage of the bladder	36 months	Not known

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A NOTE ON THE TREATMENT OF WOUNDS OF THE GENITAL ORGANS IN WARFARE

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of Geneva, Switzerland

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Wounds of the scrotum and testicle by missiles are, on the whole, relatively frequent in this war, and of course they may be accompanied by variously serious lesions of the neighboring organs. The lesions encountered offer various degrees of destruction and the complications, likewise, are many.

There may be merely a simple contusion of the scrotum, giving rise to a hæmatoma or traumatic orchitis. Not infrequently there is a simple wound of the scrotum, with or without some foreign body lodged in its cavity, with or without lesions of the urethra or hernia of the testicle.

As to the seminal gland, it may be simply contused or partially or totally destroyed. The vas deferens may be involved, that is to say, contused or divided, and I know of one case in which the penis was dislocated at the same time.

The symptoms are not usually very marked and can be summed up in slight pain, a trifling external hemorrhage, and an hæmatic tumefaction which may be quite manifest. Hernia of the testicle may be primary or secondary.

To one point I would call particular attention, and that is that death may occur from infectious complications or from associated lesions. Wounds of the scrotum are recovered from with ease and this also applies to traumatic orchitis. However, when hernia of the testicle arises, three eventualities are to be looked for, *viz.*: (1) the organ may slough; (2) become reduced spontaneously (as in the case of cerebral hernia), and (3) become grafted on a neighboring area.

When the testicle is injured to an extent beyond repair, castration must be done, but it should not be forgotten that repair may take place, although this is very likely to be followed by partial or even total atrophy of the gland. As a late consequence obstinate neuralgia may ensue, while should both testicles be injured, phenomena of eunuchism are prone to arise. Therefore, the prognosis, so far as the ultimate outcome of the case is concerned, must be more than guarded.

There are hardly ever two wounds quite the same in nature, and in each and every case, the technic will vary, according to the indications. There is a rule in these cases, which never suffers an exception, namely that conservative surgery must be foremost, for these subjects are young adults, in full genital maturity, and are to be called upon later on to play an important part in the future life of their country. The reader may smile at

this remark, but could my countrymen but know the minute care that has been taken by Germany and her subservient allies for the breeding of future "cannon food," he will do well to think twice of what I say.

In contusion of the scrotum, the treatment is usually a simple matter. Moist humid dressings applied with very slight compression are usually quite sufficient to subdue the pain and tumefaction. Should the swelling not quickly decrease, this fact indicates that there is either a hæmatoma of the scrotum or an hæmatocele of the vaginalis, an indication for incision and drainage without awaiting future developments which will surely be of septic nature, and at the same time any bleeding vessel can be ligated.

Should the reaction of the vaginalis have resulted in the production of a hydrocele, this morbid process is to be dealt with according to rules known to all. Small wounds of the scrotum heal with ease by the use of moist dressings, but in cases of large loss of scrotal tissue, simple dressings are inadequate and skin grafts must be made, which, in this region, take readily.

If a missile or other foreign body is lodged in the scrotal cavity it should be removed at once, which is a simple matter and requires no particular skill, but the treatment becomes a much more delicate question when the testicle is involved. Not uncommonly the gland, be it either intact or injured, forms a hernia through the aperture in the scrotum.

Now, no hesitation is permissible when the testicle is untouched or only slightly contused, because the only rational treatment is its reduction into the bursa and suture of the latter. The reduction should be attempted just as soon as possible in order to avoid strangulation and its shadow, sloughing, which always follows. The reduction may be delayed for a *few days until the scrotal wound has been properly cleansed* if it appears to be infected as is usually the case, but at the same time, *the vitality of the testicle must be carefully watched.*

When reduction is undertaken, the utmost gentleness must be observed. After having carefully cleansed the structures, the lower or upper angle of the scrotal wound must be enlarged by incision and the ragged edges of the vaginalis carefully evened off with scissors. With the exit of the testicle from the scrotum, all the tunics will, of necessity, be turned outward; therefore, since in the circumstances the vaginalis will form a virtual cavity, the testicle can be reintegrated if the walls of the vaginalis are first raised up and retracted.

In cases seen shortly after the receipt of the injury, it may be possible to reintegrate the testicle under its serous covering, otherwise the gland must be covered by any means possible, such as a moist dressing, and then await events. Not uncommonly, the congestion will subside in a few days, the surrounding structures will relax and the general aspect of the process will assume an aspect of excellent behavior, far from what might have been assumed when the case first came under observation. Admitting that the

testicle and its vessels *are intact, irreducibility is never an indication for primary castration.*

There is every reason to attempt reduction, even when the testicle is *contused* or offers a *superficial* wound. The parenchyma forming the hernia should be carefully reduced and the albuginea minutely sutured. One can never surmise just what this conservative treatment may hold in surprise, but the great value of the organ in question cannot but incite one to attempt conservative lines.

Such conservative treatment is out of the question when the testicle has been outside the scrotal cavity for some time, in which case it will be found to be dark in color, dried and withered. Likewise, when greatly injured, it will have emptied its contents and is reduced to a fibrous shell. In these circumstances the tissues are infected of necessity and septic complications are imminent. Therefore, the removal of the gland becomes imperative.

When considering the question of castration for any motive whatsoever, account should be taken of the condition of the fellow organ, which may in its turn be compromised in the injury.

The same principles must be our guide in the ultimate treatment of painful phenomena arising after traumata of the testicle. The pain may result from atrophied or greatly traumatized testicles, but as all this is new experience for surgeons, and as sufficient time has not elapsed for reliable data to be accumulated, we must await final judgment.

Not infrequently, neuralgic paroxysms have their starting point in the testicular stump, so that an interference for its relief is indicated *if the fellow organ is healthy.* But when only a portion of a testicle remains, the other organ having been destroyed by trauma, one should advise the patient to essay all medical means at our disposal in order to save, if possible, the remains of one testicle.

As to operative interference in wounds of the vas deferens, which is often the seat of a lesion, as well as those occurring in the scrotal urethra. Of the vas, there is little to be said. Some cases of suture in case of division of the duct have been done, but as yet we are ignorant of the ultimate outcome of these patients.

As to retention of urine of reflex nature, a few séances of aseptic catheterization will generally control the situation. Suprapubic cystotomy should be done for retention of urine following an injury to the urethra (I am, of course, only considering the treatment of these cases at an ambulance, not at a base hospital), and at a few days later the urethra can be repaired by some one of the many methods at our disposal, upon which it is quite unnecessary to insist.

ANATOMICAL METHODS OF APPROACH IN OPERATIONS ON THE LONG BONES OF THE EXTREMITIES*

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To insure absolute safety in the performance of surgical operations four requisites are necessary in the operator: First, sound anatomical knowledge; second, accurate pathological training; third, technical skill; and fourth, well-balanced judgment. Each is so important in its particular way and all are so interdependent that the loss of one of them will belittle the value of the others. For a number of years past it has been a matter of observation that many surgeons were showing a tendency to drift away from the traditions of the old school as to the necessity of a profound anatomical training as a stepping stone to the career of a surgeon. The repeated assertion that "a good anatomist was often a timid surgeon" came to have a meaning that the timidity was a direct result of the anatomical training, which we must admit is a very fallacious conclusion to draw. Observation will support the statement that the men who have left the greatest impress on scientific surgery have achieved it by contributions to anatomical improvements in technic and by additions to our knowledge of surgical pathology. And of these two the former is by no means the least important. Witness the development of the modern operations for supravaginal hysterectomy and the Wertheim operation for cancer of the uterus, and compare them with the crude procedures in vogue thirty or more years ago. In every direction we are paying more attention to anatomical details, the aim of the surgeon being to complete the operation with the least possible hurt to the surrounding structures. Some operations, such as those for radical cure of hernia, for the removal of cervical glands and the complete breast operation, are models and triumphs of clean dissection.

In visiting the important clinics of the country one cannot help being impressed by the fact that wonderfully good surgery is performed on the abdominal viscera and in some places an unusual degree of skill is shown in neck operations. On the other hand, with a few exceptions the work done on the arms and legs is not of the highest order. This deplorable condition is the result partly of want of practice and partly of deficient anatomical knowledge. During an experience of over a quarter of a century of teaching operative surgery on the cadaver to successive generations of senior students, I have clung tenaciously to the old traditions of insisting on a thorough course in the surgical anatomy of the typical operations, such as ligature of arteries and exposure of nerves and tendons, before allowing the students to indulge in the atypical operations in the abdomen and elsewhere. The course has assumed the importance of an advanced course in surgical anatomy

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of the extremities and head and neck. As a repetition of work previously touched on in the Junior year it has caused a little resentment as being superfluous. I have felt, however, that I was putting the finishing touches to an excellent anatomical training and that I could conscientiously sign my name to the diploma and certify that the recipient was reasonably safe to practise surgery. The expressions of gratitude that reach me constantly from my old pupils, as to the benefit of this training, have convinced me that the course has been a wise one, and consequently it is still followed.

During this period I have had constant opportunity of studying anatomical regions from the point of view of contemporary surgical procedures and of modifying my views as to the best way of exposing the bones and other structures. One important fact was early impressed upon me, namely, that pure anatomical facts which have apparently little surgical significance to-day may become of great importance to-morrow. The moral of which is that one cannot store one's mind too compactly with anatomical truths.

During the last few years I have interested myself with the long bones and the best routes by which they can be reached, and the following communication is the result of my studies.

The following conditions may call for operations on the long bones:

(1) *Fractures* in all phases; open or closed; recent or of old standing; ununited or united with deformity.

(2) *Osteomyelitis;* acute or chronic.

(3) *Deformities;* such as occur in rickets, bow-legs, knock-knee, etc.

(4) In *orthopædic surgery;* to attach silk ligaments or fascial strips to alleviate paralytic forms of talipes.

(5) *Tumors;* such as chondroma, osteoma, cysts, sarcomata.

Some of these affections, such as osteomyelitis and some of the tumors, have a predilection for the neighborhood of the epiphyseal lines and epiphyses, a fact which makes it necessary for us to be familiarly acquainted with the relationship of the epiphyseal lines to the joint cavities and the lines of reflexion of the synovial membranes. For example, the epiphyseal line of the proximal end of the femur lies entirely within the joint, the line of reflexion of the capsule being far distal to it in front and behind; a condition of affairs which is responsible for the frequency with which the hip-joint becomes secondarily infected in chronic osteomyelitis of the head of the femur. Further, the proximal end of the shaft which is represented by the neck of the femur in contact with the epiphyseal line is occasionally affected with acute osteomyelitis. This also lies inside the capsule and the diseased focus may point directly into the joint cavity and not burrow as it often does along the shaft below the line of attachment of the capsule. The epiphyseal line of the upper end of the humerus is within the capsule on its medial, but outside it on its lateral aspect. As a rule foci of acute osteomyelitis point outside the other large articulations.

In exposing the long bones the following principles must be scrupulously observed:

(1) *Easy Access to the Site of Fracture or Focus of Disease.*—As far as possible we should try and avoid deep wounds where shallow ones will suffice; but if anatomical structures are less damaged by employing deeper dissections, preference must be given to the latter.

(2) *Preservation of All Nerves Both Sensory and Motor.*—It might seem a superfluous refinement to allow a cutaneous nerve to influence us in the choice of an incision, but wherever possible, even cutaneous nerves should be preserved. Thus patients will often complain bitterly of numbness after complete division of cutaneous nerves, especially those supplying the hands and feet. Partial division of a cutaneous nerve is often followed by neuralgic symptoms of an intractable nature. The preservation of the motor nerves is a vital necessity. Upon this, more than on any other factor, does the future usefulness of the limb depend.

(3) *Prevention of Unnecessary Injury to Muscles.*—As far as possible the approach should be between the muscles. In some instances, however, the muscles may be split parallel to their fibres without doing any permanent damage. As an example the lower portion of the triceps brachii may be split for a considerable distance above its insertion without serious damage to its function. In situations where the fractured ends of the bones are covered by a transverse muscle, as in the upper end of the radius (supinator), an attempt should be made to peel the muscle from the bone and retract it upward or downward rather than to divide it. If it is necessary to divide a muscle the line of incision should be made as far as possible from the point where its nerve supply enters it.

(4) *The Preservation of the Vascular Supply.*—It is always wise, other things being equal, to choose a route remote from the blood-vessels. When this is impossible, they should be protected with the greatest care. To deprive a muscle or a group of muscles of their proper amount of blood will retard both the healing processes and the ultimate return of function on which the future of the limb depends.

Further, it must be borne in mind that any injury of the nutrient arteries of the bones must be avoided. This will entail careful consideration as to their origin from the main trunks and the situations where they enter the bone. Extensive denudation of the fractured ends of the bone should be avoided for the same reason.

THE UPPER EXTREMITY

THE RADIUS.—1. *Distal Extremity.*—This consists of the lower epiphysis and the contiguous part of the diaphysis. The epiphyseal line is entirely outside the articulation. The posterior surface of this extremity is occupied by grooves for the extensor tendons of the fingers, thumb and wrist (Fig. 1). The *anterior surface* is covered deeply by the pronator quadratus muscle and the tendinous insertion of the brachioradialis; also by the radial artery and the superficial and deep flexor muscles. The medial surface is opposed to the ulna with which it articulates. The *lateral surface* is prolonged into the styloid process on which is found a groove which is occupied by the tendons of the abductor pollicis longus and the extensor pollicis brevis. Into the proximal parts of the anterior and posterior lips of the groove and to

its floor the tendon of the brachioradialis is inserted. This surface is the only really accessible part of the lower end of the radius and it can be exposed by an incision carried vertically upwards from the anterior margin of the styloid process. The tendon of the brachioradialis will be exposed having medial to it the radial artery. If the artery be retracted, the pronator quadratus will be seen. The radius will be exposed between the brachioradialis insertion and the pronator quadratus (Figs. 2 and 4). This will enable the lower epiphysis and the neighborhood of the epiphyseal line to be reached with ease and safety, and also is an accessible route for osteotomies in some cases of badly set Colles' fractures.

The higher parts of the lateral aspect of the distal end of the radius can be more easily reached by a deep dissection between the brachioradialis anteriorly and the extensor carpi radialis longus posteriorly. In fact, the lateral aspect of the lower third of the radius can be safely exposed by this route. The following are the steps of the dissection (Fig. 3). Expose the tendon of the brachioradialis, and retract it anteriorly. The tendon of the extensor carpi radialis longus comes into view, passing vertically downward. This is crossed obliquely just above the base of the styloid process by the abductor pollicis longus muscle and below this by the extensor pollicis brevis. Retract the extensor carpi radialis longus medially and the abductor pollicis longus distally. This will expose the lateral aspect of the radius as far as the groove in the styloid process. If more exposure is needed the tendon of the brachioradialis can be peeled from the bone and re-attached after the operation is completed. By this procedure a larger area of bone can be exposed, but it perhaps imperils the tendinous groove in the styloid process (Fig. 1).

The posterior surface is covered by the dorsal carpal ligament and is grooved by the following tendons in order from the medial to the lateral side: the extensor digitorum communis, the extensor indicis proprius, the extensor pollicis longus, the extensor carpi radialis brevis and the extensor carpi radialis longus (Fig. 1). Superficial to these we find the dorsal carpal ligament binding the tendons down in their grooves. Above the upper edge of the dorsal carpal ligament there is a small area of the lower end of the radius that could be exposed by a careful dissection carried along the lateral border of the extensor digitorum communis tendon. The deep dissection after medial retraction of the digitorum communis would expose the extensor pollicis longus, passing downward and laterally under the dorsal carpal ligament. Just above the upper border of the dorsal carpal ligament a triangle can be made out, the base of which is formed by the upper border of the carpal ligament, the lateral side by the extensor pollicis brevis, and the medial side by the extensor pollicis longus (Fig. 5). In the floor of this triangle, a part of the posterior surface of the radius and the tendon of the extensor carpi radialis brevis can be seen. The area of bone exposed is very small, but can be enlarged by retraction of the short and long extensors of the thumb. It would hardly be wise to choose this route as a deliberate method of exposure except in rare circumstances, because it would expose the extensor tendon sheaths to the risk of damage and possible infection. Even in the cadaver it is a difficult matter to dissect this space without opening some of the synovial sheaths. The surface of the radius beneath the dorsal carpal ligament is grooved by the extensor tendons and is, surgically speaking, inaccessible.

2. *Shaft.—Anterior surface:* The proximal end of the anterior surface of the shaft is very deeply situated, being covered by the brachioradialis muscle and the muscular masses attached to its surface. The distal end is nearer the surface. The base and anterior edge of the styloid process are subcutaneous. The whole of the surface from the neck proximally almost as far as the articular margin distally is covered by the following structures in order (Fig. 2): Biceps tendon (insertion), supinator (insertion), flexor digitorum sublimis (origin), pronator radii teres (insertion), flexor longus pollicis (origin), and pronator quadratus

(insertion). The radial artery with its venæ comites lies on all of these structures and at the distal border of the pronator quadratus the artery lies on bone. The brachioradialis muscle is superficial to the radial artery in the proximal third of the forearm, but gradually passes to the lateral side to reach its insertion. Superficial to the pronator quadratus muscle we find the tendons of the flexor carpi radialis, flexor pollicis longus and the lateral tendons of the flexor digitorum sublimis (Fig. 4). It is evident that the *proximal third* of the anterior surface is inaccessible, owing to its great depth and anterior relations. The *middle third* is also quite deep but could with a little difficulty be exposed by the following dissection. Incision of the deep fascia along the medial border of the brachioradialis and retraction of that muscle to the lateral side of the forearm would expose the insertion of the pronator radii teres and the radial origin of the flexor digitorum sublimis. By dissecting between these two muscles and, if necessary, peeling the sublimis medially from its insertion, and the underlying flexor pollicis longus along with it, the surface of bone would be laid bare (Fig. 2). In the *lower third* a considerable area of bone could be exposed safely by dissecting to the medial side of the brachioradialis tendon. A strip of bone reaching from the insertion of the pronator radii teres to the base of the radial styloid process, lying lateral to the origin of the flexor pollicis longus and the insertion of the pronator quadratus would be accessible (Figs. 2 and 4). The lower part of this area has already been described in the section dealing with the surgery of the distal end of the bone.

Posterior surface: This surface in its proximal half is not so deeply imbedded in muscles as the anterior surface. A study of Fig. 1 will show the muscles attached to it. The insertion of the supinator muscle occupies nearly all the proximal third. Distal to this, in order, we find the origins of the abductor pollicis longus and the extensor pollicis brevis arising from a strip on the medial half of the bone. Opposite the origin of the abductor pollicis longus we find the insertion of the pronator radii teres into the lateral margin of the shaft along a narrow roughened ridge. The part of the shaft below the insertion of the pronator radii teres to which no muscles are attached is covered by the fleshy bellies of the abductor pollicis longus and extensor pollicis brevis on their way to the groove on the outer aspect of the styloid process. Between the origin of the abductor pollicis longus and the insertion of the pronator radii teres, a narrow strip of bone is seen to which no muscle is attached. This is continuous with the large bare area below. This narrow strip of bone and a considerable area of the bare surface below it can be exposed by the following procedure: The lateral border of the extensor digitorum communis tendon is exposed, at a point corresponding to the junction of the middle and lower thirds of the forearm, by an incision which follows a line from a point corresponding to the middle of the posterior aspect of the wrist to a point about a finger's breadth anterior to the external epicondyle of the humerus (Fig. 5). If this tendon is followed upward it is easy to separate it from the tendon of the extensor carpi radialis brevis. The common extensor of the fingers is retracted medially and the short radial extensor laterally. The abductor pollicis longus is then fully exposed and on the lateral border of the radius the insertion of the pronator radii teres is seen. By retracting the abductor pollicis longus distally and medially a considerable area of the posterior surface of the radius can be exposed (Fig. 7). If necessary, this muscle can be peeled from the bone towards the interosseous membrane. A study of Figs. 5, 6, and 7 will simplify the understanding of the text. By following the line of separation between the extensor digitorum communis and the extensor carpi radialis brevis and longus as far up as the lateral epicondyle of the humerus (Fig. 5) and retracting the former muscle medially, the supinator muscle will come into view as high as the neck of the radius (Fig. 6). In this way all the

muscles arising from the posterior surface of the radius can be exposed. By detaching the origin of the common extensor from the external epicondyle this muscle can be retracted still further medially just as far as the blood-vessels and nerves, which enter it at the level of the lower border of the supinator, will endure the traction. By this manœuvre the annular ligament of the radius comes into view and distal to this a more extended view of the supinator muscle (Figs. 6 and 7). The incision from end to end will pass along an area free from blood-vessels of any size and will not imperil the nerve supply of any of the muscles brought into view. By means of this dissection a little more than the proximal half of the shaft becomes accessible for surgical procedures if care is taken in exposing the bone covered by the supinator muscle.

It will be convenient here to describe the nerve supply to the muscles concerned and show how we can avoid injuring them. The radial nerve (O. T. musculospiral) gives off muscular branches to the brachioradialis and to the extensor carpi radialis longus near their origins, as it lies between them and the brachialis muscle in front of the lower end of the humerus. In the hollow of the elbow it divides into two branches, viz.: the superficial ramus (O. T. radial nerve) which is entirely cutaneous in its distribution and the deep ramus (O. T. posterior interosseous nerve) which is entirely muscular.

The superficial ramus passes down the forearm deeply placed under cover of the brachioradialis muscle. It is placed to the lateral side of the radial artery. In the distal third of the forearm it passes backward under the brachioradialis and pierces the deep fascia to become subcutaneous. It may be injured in operations on the lower third of the lateral aspect of the shaft.

The deep ramus passes distally and posteriorly. It gives off immediately branches to the extensor carpi radialis brevis and to the supinator. It then penetrates the substance of the supinator on its lateral aspect, just below the level of the head of the radius, and lies embedded in the muscular fibres almost as far as its lower border, where it emerges under cover of the extensor digitorum communis to which it gives branches at once (Fig. 7). Then it passes distally under the name of the posterior interosseous nerve, superficial to the abductor longus pollicis and the extensor brevis pollicis, to which it gives branches which penetrate the muscles on their superficial aspects; it then passes deeply under cover of the extensor longus pollicis and the extensor indicis proprius to which it gives branches which penetrate them on their deep aspects. It ends on the back of the carpus under the extensor tendons in a gangliform enlargement.

A study of Fig. 7 will show the arrangement of the nerves. It will be seen that separation of the supinator and the abductor longus pollicis can be carried to a high point if care is taken of the dorsal interosseous nerve. As a matter of fact, retraction of the extensor communis digitorum is resisted opposite the lower border of the supinator, because both the nerves and arteries enter the muscle at this point. This is the danger zone. Starting from here one can follow the course of the radial nerve, both proximally and distally. The distal portion of the dorsal interosseous is quite slender and is bound down to the posterior surface of the deep muscles by a fairly strong band of fascia which it is unwise to attempt to disturb. The proximal portion courses through the supinator very obliquely. It lies about 2 cm. below the joint line on the lateral aspect of the radius and about 5 cm. below the line on its posterior aspect.

In actual operative work on the area of bone covered by the supinator, the muscular fibres are usually divided until the radial nerve comes into view when it is carefully retracted. It would be a better plan to peel the muscle from the bone and retract it either proximally or distally. We have proved the feasibility of this both in the dissecting room and at the operating table. One should avoid

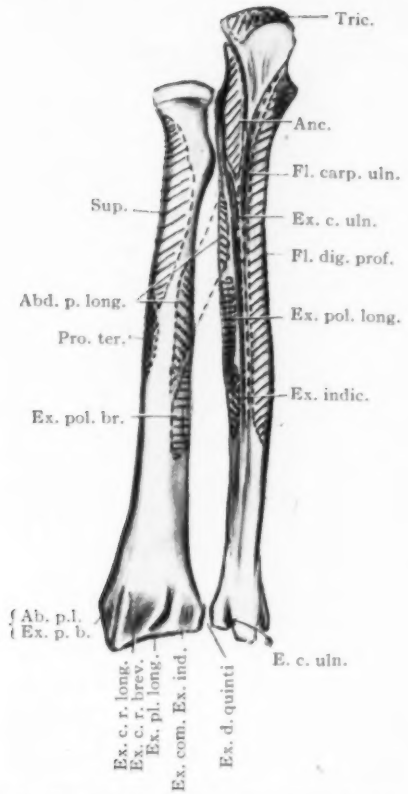


FIG. 1.—Posterior view of radius and ulna showing origins and insertions of muscles. In the picture of the ulna it will be seen that a part of the shaft medial to the posterior subcutaneous ridge is shown, with the origins of the flexor carpi ulnaris and the flexor digitorum profundis. The abbreviations in this and all subsequent figures refer to the new anatomical nomenclature followed by Cunningham. For all the plates I am indebted to Prof. Wm. Keiller. Most are modifications of the excellent plates in Cunningham s Anatomy. A few are from Spalteholtz. Some are from original dissections. The sections of the joints are from Beesly and Johnston.

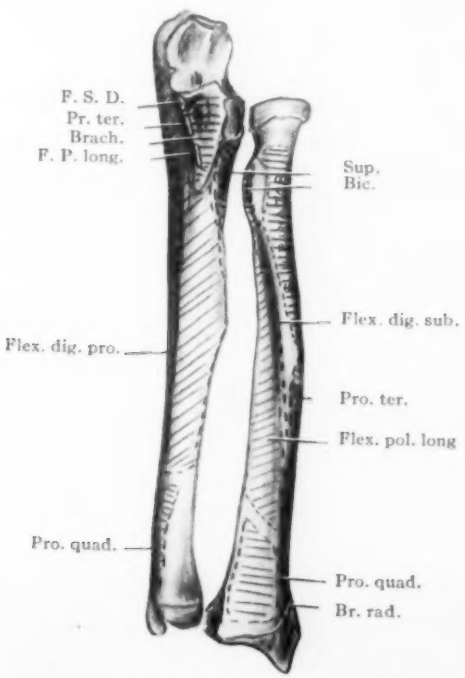


FIG. 2.—Anterior view of the radius and ulna.

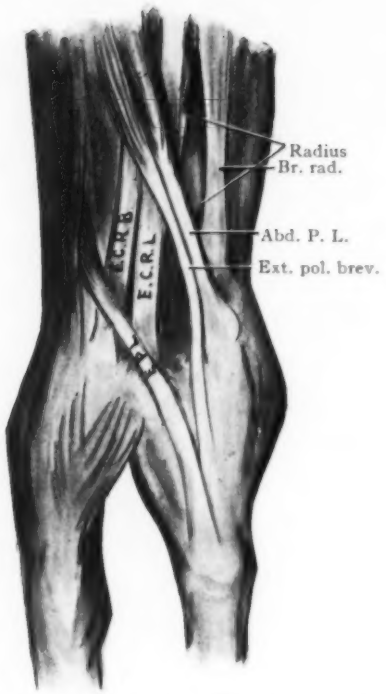


FIG. 3.—Posterolateral view of a dissection of the lower part of the forearm just above the wrist. A considerable area of radius can be seen in the interval between the brachioradialis and the extensor carpi radialis longus. This area is bounded below by the abductor pollicis longus (original dissection).

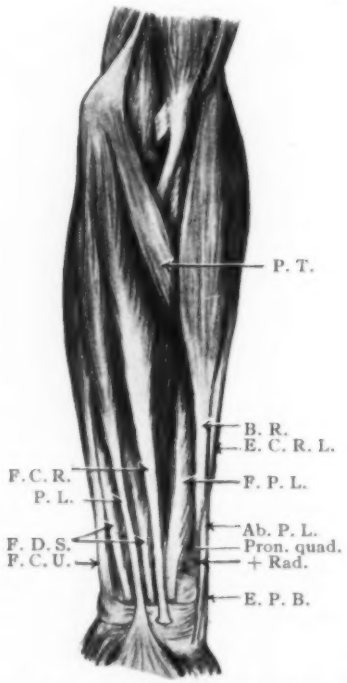


FIG. 4.—Dissection of the muscles on the anterior aspect of the forearm and wrist. The arrow marked + Rad. points to the medial side of the brachioradialis tendon and its point shows an interval between the brachioradialis and the pronator quadratus. By retracting the brachioradialis laterally and peeling the pronator quadratus medially from the surface of the bone a considerable area of the anterior surface of the radius can be exposed.

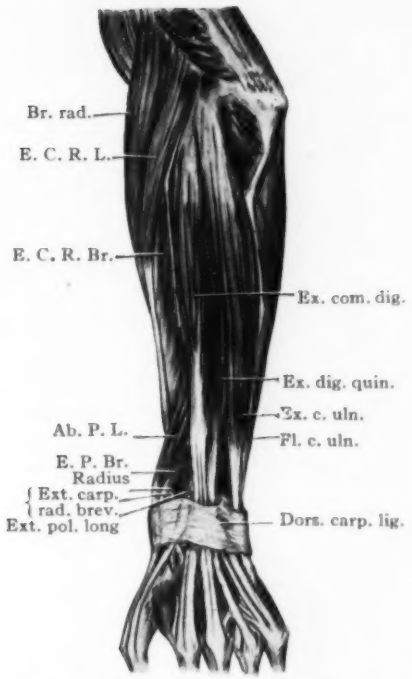


FIG. 5.—Dissection of the muscles of the posterior aspect of the forearm and wrist. Above the dorsal carpal ligament, a portion of the lower end of the radius can be seen lying in an irregular quadrilateral area bounded by the extensor pollicis longus medially, the upper edge of the dorsal carpal ligament distally, the extensor carpi radialis brevis laterally and the extensor pollicis brevis proximally. In the upper part of the arm, the aponeurotic interval between the extensor digitorum communis and the extensores carpi radialis brevis and longus is shown by an accentuated white line.

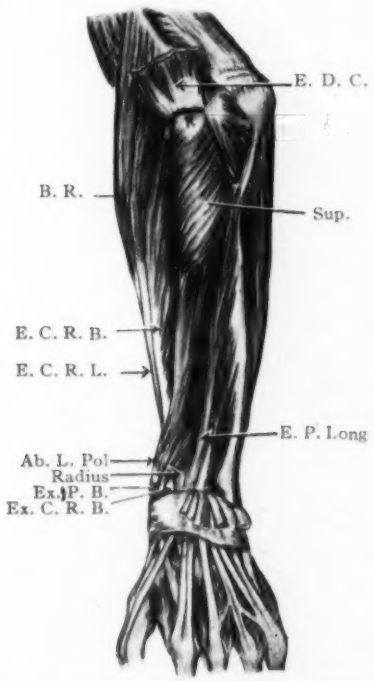


FIG. 6.—Deeper dissection of the muscles on the posterior surface of the forearm. The extensor digitorum communis has been removed and its origin proximally (E. D. C.) thrown upward, exposing the head of the radius (R) covered by the annular ligament. The distal end of the muscle is thrown over the dorsal carpal ligament. A clear view is shown of the surface of the radius shown in Fig. 5. The whole extent of origin of the abductor pollicis longus is exposed, and proximal to this the posterior surface of the supinator muscle as high as the neck of the radius. By retracting the contiguous margins of the abductor pollicis longus and the extensor carpi radialis brevis from one another, a considerable area of the bone can be exposed. This is shown in Fig. 7.

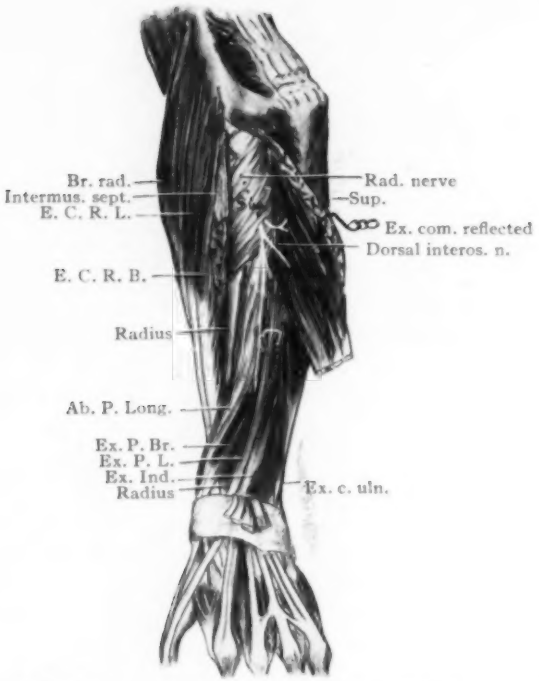


FIG. 7.—A dissection of the muscles of the posterior surface of the forearm, showing (1) an area of radius exposed above the upper edge of the dorsal carpal ligament, (2) a large area of the shaft of the radius exposed below the supinator muscle, by separating the abductor pollicis longus and the extensor carpi radialis brevis from one another, (3) the course of the radial nerve through the muscular fibres of the supinator (shown by an oblique dotted line); and (4) the exit of the dorsal interosseous nerve from the supinator muscle and the distribution of the muscular branches to the extensor digitorum communis, abductor pollicis longus and the extensor pollicis brevis.

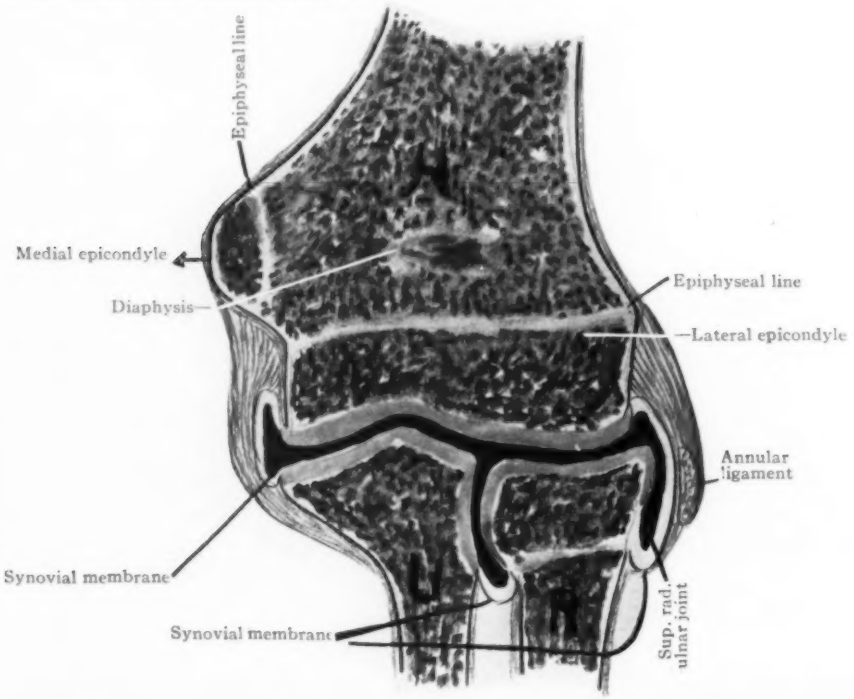


FIG. 8.—Represents a coronal section of the elbow-joint. The downward growth of the shaft between the medial epicondyle and the trochlear surface is well depicted. The lateral epicondyle is below the epiphyseal line and belongs to the epiphysis. The medial epicondyle does not belong to the epiphysis. It will be seen that the lateral epicondyle is the key to the situation in operations for fixation of epiphysis. The shaft above the epicondyle is accessible on either side along the supracondylar ridge of bone.

pulling on the nerve too vigorously. In one of our cases the extensor muscles were temporarily paralyzed after a bone plating operation in this region.

3. *Proximal extremity* (head and neck): The upper epiphysis of the radius is entirely within the synovial cavity of the elbow joint (Fig. 8). The head of the bone is firmly grasped by the annular ligament which holds it firmly in the radial notch of the ulna. The ligament also encircles the proximal part of the neck of the bone. The anterior surface of the head and neck is so deeply placed as to be inaccessible. Posteriorly the head can be palpated easily and its rotation felt when the forearm is pronated and supinated. On this surface the supinator muscle passes almost as high as the margin of the head. Covering both head and neck and supinator muscle is the aponeurosis of origin of the extensor digitorum communis. This part of the bone can be exposed by a vertical incision carried distally from the lateral epicondyle for a short distance. By splitting the attachment of the extensor digitorum communis, the annular ligament of the radius and supinator muscle are exposed. After cutting the annular ligament the head comes into view. If a view of the neck and the contiguous part of the shaft is required the fibres of the supinator are detached and retracted distally or divided. The position of the deep branch of the radial nerve must be remembered.

SUMMARY OF CONCLUSIONS

The distal end of radius is accessible: (1) In front of the base of the styloid process by passing between the brachioradialis insertion and the radial artery and exposing the bone to the lateral aspect of the pronator quadratus (for Colles' fracture and osteomyelitis of epiphysis).

(2) Above the base of the styloid process by passing between the tendon of the brachioradialis and the extensor carpi radialis longus. At least the lower third of the lateral aspect of the bone can be explored if this incision be prolonged upwards (for Colles' fracture and osteomyelitis of diaphysis).

(3) Over a small area of the posterior surface just above the dorsal carpal ligament between the extensor pollicis longus and extensor pollicis brevis (of purely academic interest).

The shaft of the radius is accessible: (1) Along the lower third of its lateral border (see procedure No. 2 for distal end of bone).

(2) Along a narrow strip of the posterior surface situated between the insertion of the pronator teres and the origin of the abductor pollicis longus. The dissection passes superficially to the lateral side of the extensor digitorum communis, deeply between the abductor pollicis longus and the extensor carpi radialis brevis. By retracting the abductor pollicis longus a considerable area of the radius covered by this muscle can be exposed. The *middle third of the shaft* can be reached by this route.

(3) The upper third of the posterior surface can be reached by a prolongation upward of the incision in No. 2 as far as the external epicondyle. The extensor digitorum communis is separated from the extensores carpi radialis longus and brevis and from the epicondyle and retracted medially. The supinator is exposed and retracted or divided secundum artem.

The proximal end of the radius is accessible: (1) From behind by splitting the aponeurosis of origin of the extensor digitorum communis from the external epicondyle by a vertical cut. If necessary open the joint by cutting

the annular ligament and expose the head of the bone. To expose the neck, divide or retract the supinator muscle.

THE ULNA.—The shaft and both extremities of the ulna are subcutaneous from end to end. The epiphyseal line at the distal end of the bone is extra-articular everywhere except over a small area on its radial aspect. The proximal epiphyseal line is entirely extra-articular. The best method of exposing the bone is along its subcutaneous margin. In the distal part the incision passes between the tendons of the flexor and extensor carpi ulnaris. Care must be taken to avoid injuring the dorsal cutaneous branch of the ulnar nerve which passes backward beneath the tendon of the flexor carpi ulnaris and becomes cutaneous in the distal fourth of the forearm. In plating fractures near the middle of the bone care must be taken not to disturb unnecessarily the muscle attached to its anterior surface (flexor digitorum profundus), through the substance of which the nutrient artery passes to enter the arterial foramen which is situated a little proximal to the middle of the bone. In operations on fractures of the olecranon process care must be taken not to injure the ulnar nerve. As the nerve passes distally between the two heads of the flexor carpi ulnaris it lies on the medial aspect of the base of the olecranon. It may be in real danger during the operation of subcutaneous wiring from side to side.

THE HUMERUS.—1. *Distal Extremity.*—The capitulum and the trochlea form the articular surface of the lower end of the humerus. They lie entirely within the capsule of the joint. The lateral epicondyle (the centre of ossification for which appears about the twelfth year) rests in close contact with the capitulum and lies outside the synovial cavity. The capitulum, trochlea and lateral epicondyle form the lower epiphysis. The medial epicondyle (the centre of ossification of which appears about the sixth year) is separated from the centres of the lower epiphysis by a growth downward of the shaft of the bone (Fig. 8). The line of attachment of the synovial membrane follows the lateral margins of the capitulum and the trochlear surfaces accurately. In front it is attached to the margin of the fossa radialis on the lateral side, thence passes up almost to the apex of the coronoid fossa and thence down to the margin of the trochlea on the medial side. On the posterior surface the attachment follows the margin of the capitulum until it reaches the edge of the trochlear surface, thence upward to the apex of the olecranon fossa and downward to the medial margin of the trochlea. Fig. 8 shows accurately the relationship of the lower epiphysis to the shaft and to the synovial cavity. The epiphyseal line is a considerable distance outside the joint line on the lateral side and just outside it on the medial side. In front and behind, the epiphyseal line is intra-articular. In cases of separation of the lower epiphysis the lateral epicondyle, which forms part of it, is also displaced. The medial epicondyle remains attached to the shaft. Both radial and ulnar collateral ligaments remain for the most part intact, and both ulna and radius are displaced with the epiphysis. If operative measures are deemed necessary, the safest and simplest method is to reduce the epiphysis by traction on the forearm and forced flexion, and then to drive a nail through the lateral epicondyle through the epiphysis into the shaft of the bone. The nail will not enter the joint cavity. Fractures through the lateral condyle usually start in the groove between the capitulum and the trochlea. They pass upward and laterally, severing the capitulum and lateral epicondyle and part of the shaft from the rest of the bone. They can be treated by a nail driven obliquely through the lateral epicondyle into the shaft. The joint is not entered. Fractures through the trochlear surface commence in the deep notch in its centre which receives the wedge-shaped edge of the ulna. A simple fissure may start here which passes upward and medially into

the shaft, separating part of the trochlear surface and medial condyle from the rest of the shaft. This can be treated without opening the joint by driving a nail through the medial epicondyle upward and laterally into the shaft. T and Y fractures start at the same point in the trochlear surface. The line of fracture bifurcates medially and laterally at the upper end of the coronoid and olecranon fossa and passes to the sides of the shaft. The result is equivalent to a transverse fracture above the condyles with a vertical fissure into the joint. They can be fixed by nails which need not penetrate into the joint cavity. One nail enters at the lateral epicondyle and passes transversely across the capitulum and trochlear surface. Another enters at the lateral epicondyle near the first and passes upward and medially through epicondyle and lower end of the shaft. Fractures of the shaft at a higher point than the olecranon fossa are best treated by splitting the triceps vertically in the middle line and plating the bone. In the description of the shaft of the humerus this will be treated more in detail. *It will be seen that the lateral epicondyle is the key to the situation in the treatment of most of these fractures.*

2. *Shaft.*—The insertion of the deltoid muscle into the lateral aspect of the shaft of the humerus just above the radial groove marks a point in the bone just above its middle. It serves as a convenient landmark to locate fractures of the shaft of the bone. It will be employed in the following description as a convenient point around which to group a number of important anatomical structures.

A study of the *posterior surface* of the humerus (Fig 9, *B*) shows that the medial head of origin of the triceps is attached to the whole aspect of its lower third, and reaches proximally a point a little above the middle third, medial to the radial groove. Lateral to the radial groove from below upward can be seen part of the origin of the brachialis muscle, part of the deltoid insertion and the lateral head of origin of the triceps. The upper end of the last-named reaches almost as far as the insertion of the teres minor, which abuts directly on that of the infraspinatus. The radial groove occupies a very important position on the posterior surface of the bone. It is very oblique and occupies approximately the middle third of the shaft. In it lie the radial nerve and the arteria profunda brachii. A line drawn vertically upward along the middle of the posterior surface of the shaft of the humerus would touch the groove at a point near the lower part of the deltoid insertion. Near this point also an arterial foramen in the bone is found in the groove. The radial groove contains structures so essential to the future well-being of the limb that it should never be interfered with unless the radial nerve has been injured in its course along it. It would therefore appear that the posterior aspect of the shaft in the neighborhood of the groove should be avoided in choosing an operative field. Below the groove the bone is covered by the medial head of the triceps, the fibres of which pass into the deep surface of a broad tendon, which is inserted into the olecranon process. Access to this portion of bone is feasible and comparatively easy if the muscle is split vertically. If the line of cleavage is carried upward a little medial to the centre of the posterior surface of the arm the bone can be exposed almost as high as the deltoid insertion without opening the radial groove. The split in the triceps does not appear to injure the nerve supply to the muscle because the nerves distributed to the medial head pass vertically downward in the muscular fibres parallel to the incision (Fig. 10).

The *anterior surface* of the bone is shown in Fig. 9, *A*.

(*a*) The *lower half* is covered by the origin of the brachialis muscle from the insertion of the deltoid proximally to the elbow-joint line distally. Proximally the origin of the brachialis forms a V, the arms of which clasp the insertion of the deltoid. The medial portion of this V runs upward almost as high as the upper

part of the deltoid insertion. Medial to it, is the insertion of the coracobrachalis muscle. Occupying narrow strips of the lateral aspect of the lower part of this surface are the origins of the brachioradialis proximally and the extensor carpi radialis longus distally. Between the brachialis and the two last-named muscles lies the radial nerve. Superficial to the brachialis muscle lie the muscular belly of the biceps, the brachial artery with its venæ comites and the median nerve; also the ulnar nerve at its upper part. The artery and nerves are on the medial aspect of the biceps muscle. From the artery passes a branch to an arterial foramen in the bone. This trunk penetrates the upper and inner part of the brachialis muscle. The upper end of the brachioradialis marks the position where the radial nerve pierces the intermuscular septum to get to the front of the arm. Superficially, this point may be represented as the junction of the upper and middle thirds of a line drawn from the external epicondyle to the deltoid insertion. The only accessible part of the anterior surface of the bone is represented by an area on its upper and lateral aspect medial to and below the deltoid insertion. This surface is covered by the brachialis muscle. This accessible area can be reached by an incision along the lateral aspect of the biceps muscle between it and the deltoid insertion (Figs. 11 and 12). The incision can be carried downward as far as safety allows. It will expose the insertion of the deltoid and the origin of the brachialis muscle which embraces it. The brachialis can then be split or peeled away from the bone. The musculocutaneous nerve will be retracted with the biceps and will be in no danger. The nerve supply to the brachialis (from the musculocutaneous and from the radial) will also be safe. If necessary, the insertion of the deltoid can be peeled from the bone.

(*b*) The *upper part* of the anterior surface of the humerus (Fig. 9, *B*) shows the intertubercular groove in which rests the long tendon of the biceps. The insertions of the pectoralis major (to the lateral lip), of the latissimus dorsi (to the floor) and the teres major (to the medial lip) can be seen. The pectoralis major covers the whole of this area as far as the lateral lip and the groove can only be exposed after the division of its tendon of insertion (Fig. 11). Proximally to the insertion of the teres major, that of the subscapularis into the smaller tubercle can be seen. An area on the outer surface of the upper third of the shaft bounded by the deltoid insertion distally, the insertions of the supraspinatus, infraspinatus and teres minor proximally, the lateral lip of the intertubercular groove anteriorly and the lateral head of the triceps posteriorly is free from any muscular attachments. It is covered by the muscular mass of the deltoid. Winding round the upper part of this area just below the tubercles are the nerve (axillary) and the artery (art. circumflex post.) which supply the deltoid. The part of the bone in contact with these structures is the surgical neck. The nerve and artery come from the axilla by passing through the quadrilateral space. A study of Fig. 10 will show that an attempt to reach the surgical neck of the humerus by an incision along the posterior border of the deltoid would invite disaster by endangering the nervous and vascular supply to the deltoid. The upper portion of the shaft below the surgical neck is accessible by this route. If care is taken to keep superficial to (*i.e.*, anterior to) the lateral head of the triceps the radial nerve would be avoided. It would, however, be a difficult route and should be reserved for special cases of open fracture with the wound in this situation.

The best route both for the surgical neck and for the upper portion of the shaft as low down as the insertion of the deltoid is in front. If an incision is made between the pectoralis major and deltoid it can be carried upward and downward as far as may be required. In the lower part of the field the bone can be exposed with ease between the insertion of the deltoid and the medial head of the origin of the

brachialis. A little more proximally the bone can be exposed lateral to the insertion of the pectoralis major by vigorous lateral traction of the deltoid. The pectoralis major covers the anterior part of the surgical neck. The lateral aspect of the neck may be brought into view by retraction of the deltoid (or, better still, by transverse section of the anterior part of the deltoid near its origin from the clavicle and acromion process). If this is done the nerve supply to the muscle will not be hurt. Ample room is obtained and subsequent suture of the muscle will restore its function. Figs. 11 and 12 show such a division of the deltoid with thorough exposure of the tubercles and surgical neck of the humerus. Many surgeons prefer to split the deltoid and to approach this aspect of the shaft on its outer aspect. This has the grave objection that all the muscular fibres in front of the incision will atrophy.

3. *Proximal Extremity.*—The proximal extremity of the humerus consists of the head and the larger and smaller tubercles (Fig. 9). Below the tubercles the contracted portion of the shaft is called the surgical neck. The head consists of about one-third of a spheroid. It is attached to the posterior medial and upper end of the shaft and the centre of the spheroid points backward and medially. It is covered with articular cartilage. Around its margin is a shallow groove well marked above, but smooth with the shaft below. This is known as the anatomical neck and to it the capsule of the joint is attached. Lateral to the groove is the prominence of the greater tubercle above, and the lesser tubercle in front. Between the tubercles is the intertubercular groove (bicipital). The head and the greater and lesser tubercle form the upper epiphysis which sits on the pointed end of the diaphysis like a cap. The epiphyseal line lies within the articulation on the medial aspect of the joint, but well outside the joint on the lateral aspect. In front it is in direct relationship with the intertubercular (bicipital) groove and hence with the joint. In cases of separation of the proximal epiphysis the proximal end of the diaphysis is usually displaced laterally and upward and lies under the deltoid muscle. The epiphysis is tilted sideways. In cases where operation is necessary, the deltoid fibres can be split for a limited space over the outer aspect of the joint just below the tip of the acromion process. If the case is recent, traction on the shaft will draw the upper end of the diaphysis downward. A sharp hook should now be placed into the greater tuberosity and by pulling downward the epiphysis can be replaced on the upper end of the shaft. It may be sutured in position by silver wire or kangaroo tendon or nailed to the shaft by a peg. There is no risk of opening the joint. In old-standing cases where we are unable to dislodge the upper end of the diaphysis by traction and where quite a long deltoid incision would be needed to give sufficient room, it would be better to make a vertical cut along the anterior border of the deltoid through which the muscle could be separated from the pectoralis major, and to supplement this by a transverse incision just below the acromioclavicular arch along which the deltoid could be divided and retracted posteriorly and distally, toward its vascular and nervous supply. By this means a perfect view of the upper end of the shaft of the humerus, surgical neck and tubercles would be obtained without permanent damage to the muscle. Subsequent suture would restore the integrity of the deltoid completely.

The region of the intertubercular (bicipital) groove and the lesser tubercle can be exposed by an incision between the deltoid and pectoralis major. The long tendon of the biceps comes into view as it passes downward between the tubercles. The joint can be opened by incising the capsule along the tendon. By rotating the humerus outward the lesser tubercle with the insertion of the subscapularis into it comes clearly into view.

RECAPITULATION

From the foregoing we may safely draw the following conclusions as to the safest methods of exposing the humerus:

A. Shaft.—(1) In the *lower third,* the bone can be reached safely by the posterior route, the deep dissection splitting the triceps muscle parallel to its fibres.

(2) In the *middle third,* one has choice of two routes: (*a*) the safest is the anterior which passes between the biceps and the insertion of the deltoid in its upper part and along the outer edge of the biceps in its lower part. The bone is exposed medial to the deltoid insertion and laid bare by splitting or peeling off the origin of the brachialis muscle. (*b*) The lower part of this area can be reached from behind by splitting the triceps. The field of operation is, however, limited above by the radial groove which is too near for safety.

(3) In the *upper third,* the anterior route between the pectoralis major and the deltoid is the best and the safest. The route along the posterior margin of the deltoid endangers the nervous and vascular supply to the muscle too seriously. It should not be forgotten, however, that if due care is exercised the bone *just above* the deltoid insertion can be exposed with comparative safety by dissecting carefully between the posterior edge of the deltoid and the lateral head of the triceps.

B. Articular Ends.—(1) *Lowr articular end:* The lateral aspects of the condyles can be reached through small incisions directly over their prominent subcutaneous parts. If necessary, the incisions can be carried upward along the external and internal muscular septa and the deep dissection carried to the bone along this plane. The soft parts can be separated from the bones on their anterior and posterior aspects, and sufficient room obtained to treat foci of osteomyelitis, or in the case of fractures to fasten the fragments together with screws or nails. Plating is difficult through such incisions. To apply a plate properly, as may be required in T-fractures, the best route is a posterior vertical incision which splits the triceps muscle near its insertion.

(2) *Upper articular end:* An incision along the anterior margin of the deltoid gives the best exposure in most cases. If supplemented by a transverse cut backward through the deltoid muscle near its origin, the exposure of the upper articular extremity is so complete that fractures of the anatomical neck and of the tubercles and foci of osteomyelitis can be dealt with in a very satisfactory manner. In uncomplicated cases of fracture of the greater tubercle, a small puncture might be made through the deltoid and a nail driven through the tubercle into the shaft to pin it in place. The head of the nail can be left outside the skin incision to facilitate removal when the bony surfaces have united.

THE LOWER EXTREMITY

THE TIBIA.—1. *Distal Extremity.* This is roughly quadrangular in shape. The lower surface is covered with cartilage and articulates with the talus. The *an-*

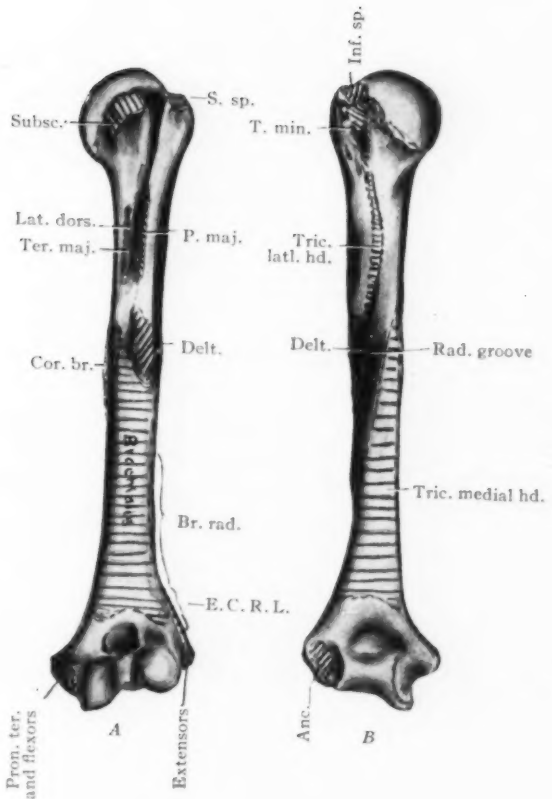


FIG. 9.—Anterior (*A*) and posterior (*B*) view of the humerus showing muscular attachments. Notice the strategic position of the insertion of the deltoid muscle as an aid to group the anatomical structures. The radial groove is shown in relief in the posterior view.

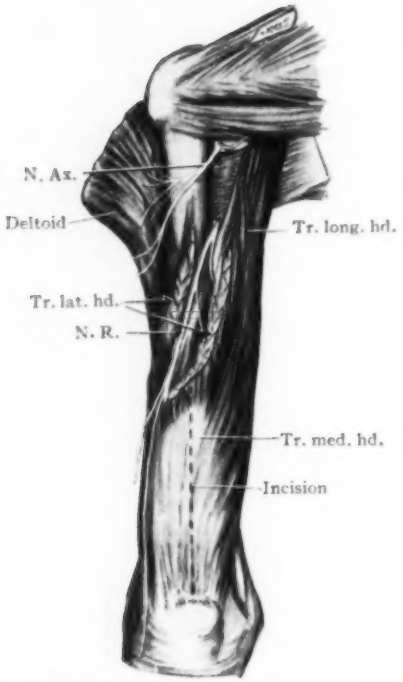


FIG. 10.—Dissection of the muscles on the posterior aspect of the arm. The medial head of the triceps has been left undisturbed. A dotted line running vertically shows the method of exposing the lower third of the shaft of the bone. The radial groove has been opened by dividing the lateral head of the triceps, and the radial nerve is exposed. The deltoid muscle has been severed from the acromion process and spine of the scapula, and retracted forwards. The nerves supplying the muscle are shown. They are derived from the axillary nerve, the trunk of which can be seen passing backwards through the quadrilateral space. Between the lateral head of the triceps and the posterior border of the deltoid near its insertion the shaft of the bone is accessible for a short distance.

FIG. 11.—A dissection of the muscles on the anterior aspect of the arm. The insertion of the pectoralis major has been left intact. Above it the tendons of the long and short heads of the biceps are shown. The deltoid muscle has been detached from the clavicle and acromion and thrown backward, exposing the upper end of the shaft of the humerus and the greater tubercle. The axillary nerve is shown. The nervus cutaneus antebrachii lateralis (O. T. musculocutaneous) is shown near the bend of the elbow.

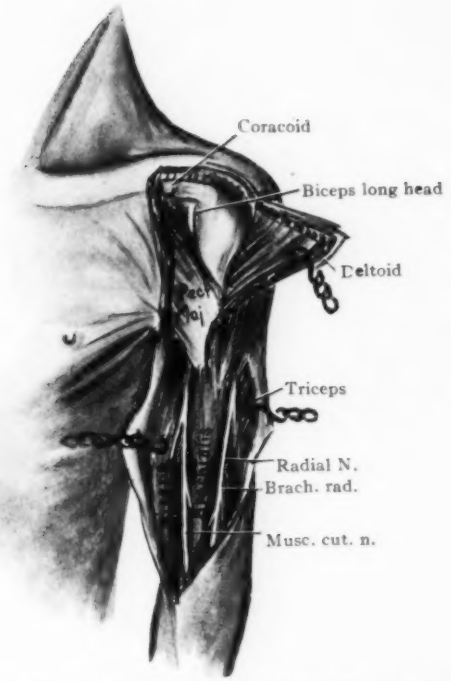


FIG. 12.—Dissection of the anterior surface of the arm to show the method of access to the upper two-thirds of the shaft of the humerus by a safe route. The deltoid muscle has been divided near its clavicular and acromial origin and retracted laterally. The belly of the biceps muscle has been retracted medially. The upper end of the shaft of the humerus and the greater tubercle is exposed. By working between the insertion of the pectoralis major and deltoid, still more of the shaft could be exposed, and by splitting the brachialis distally along the same line, the anterior surface of the shaft could be exposed to a low level. With reasonable care there would be no danger of injuring the musculocutaneous or radial nerves (original dissection).

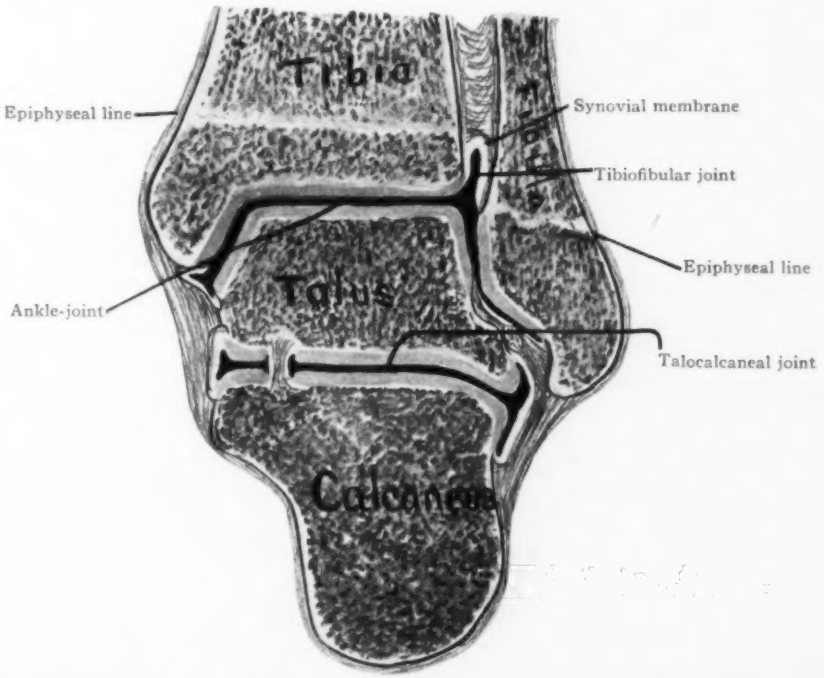


FIG. 13.—Represents a coronal section of the ankle-joint. It shows that the epiphyseal line of the distal end of the tibia is entirely outside the joint cavity. That of the fibula impinges on the joint on its medial aspect. Note the prolongation of the lower tibiofibular joint almost as high up as the epiphyseal line of the tibia.

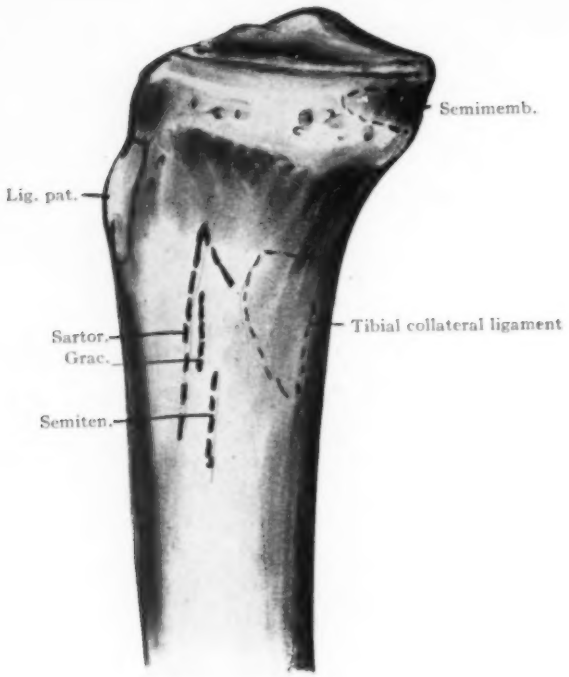


FIG. 14.—Represents the medial surface of the proximal end of the tibia. The area between the insertions of the sartorius and the ligamentum patellæ gives access to the upper end of the diaphysis and the epiphyseal line. The medial surface of the shaft below the insertion of the semitendinosus is free from muscular attachments.

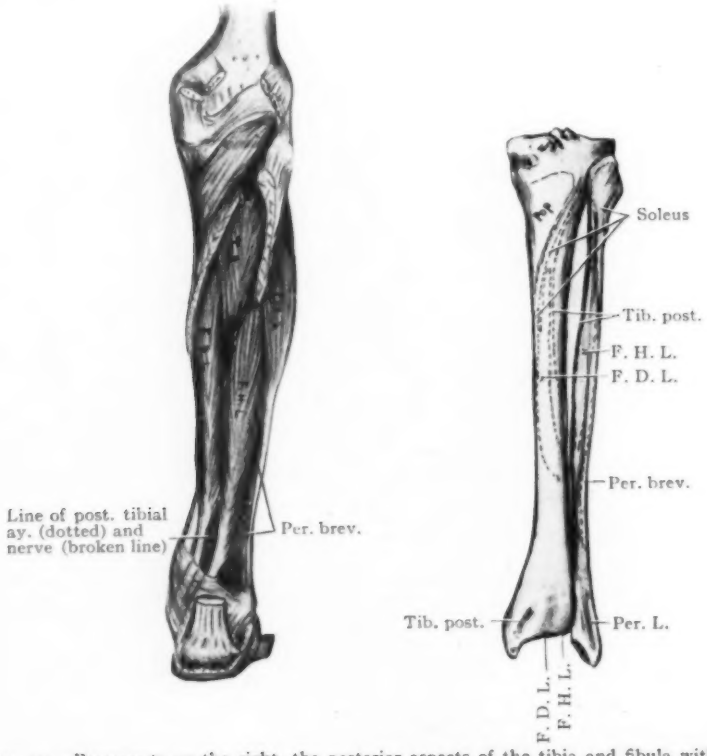


FIG. 15.—Represents on the right, the posterior aspects of the tibia and fibula with the muscular attachments to the bones; on the left a dissection of the deep muscles of the posterior aspect of the leg. On the bones the large area of the posterior aspect of the lower third of the tibia free from muscular attachments is well shown. At its distal extremity the tendinous grooves are seen. On the posterior aspect of the lateral malleolus the groove for the peronei tendons is seen. The muscular dissection (left) shows by dotted and broken lines the position of the posterior tibial artery and the tibial nerve, lying between the tendons of the flexor digitorum longus and flexor hallucis longus. It is through this interval that the bone is exposed for tendon implantation.

FIG. 16.—Represents a dissection of the muscles on the front of the leg. It shows also the subcutaneous portion of the medial surface of the tibia. Just above the ankle-joint the tendons are bound down by the ligamentum transversus cruris. Here the lines of the anterior tibial artery and the deep peroneal nerve are represented by dotted and broken lines. The bone (tibia) is exposed by passing between the tendons of the tibialis anterior and the extensor hallucis longus and retracting the tendon of the hallucis to the lateral side.

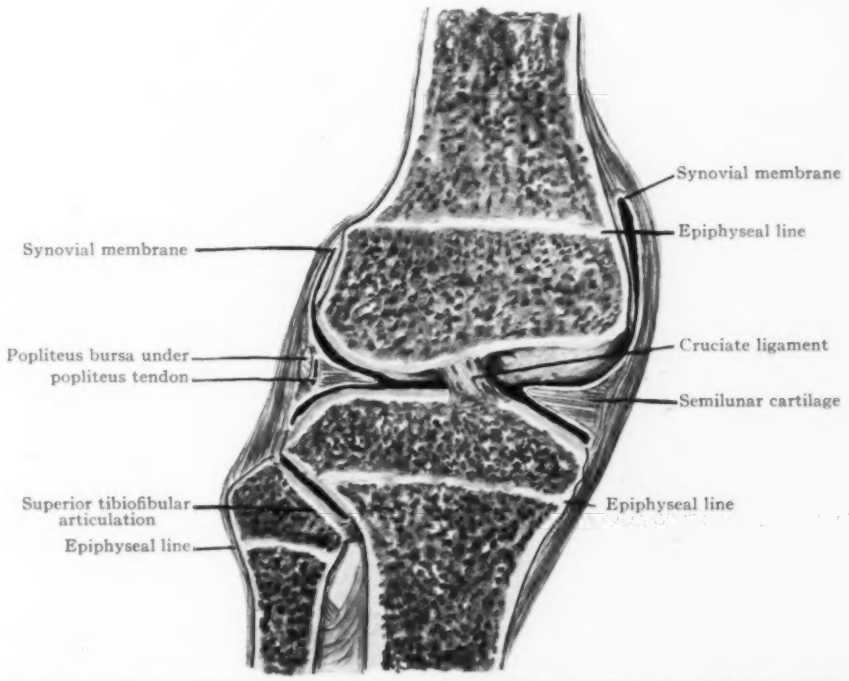


FIG. 17.—Represents a coronal section of the femur and tibia and fibula through the knee-joint. The epiphyseal line of the tibia is extra-articular as regards the knee-joint. On its lateral side it communicates with the proximal tibiofibular joint. The epiphyseal line of the fibula is extra-articular. The epiphyseal line of the femur is extra-articular on the lateral side; on the medial side the reflexion of the synovial membrane passes proximal to it. A study of Fig. 19 will explain this.

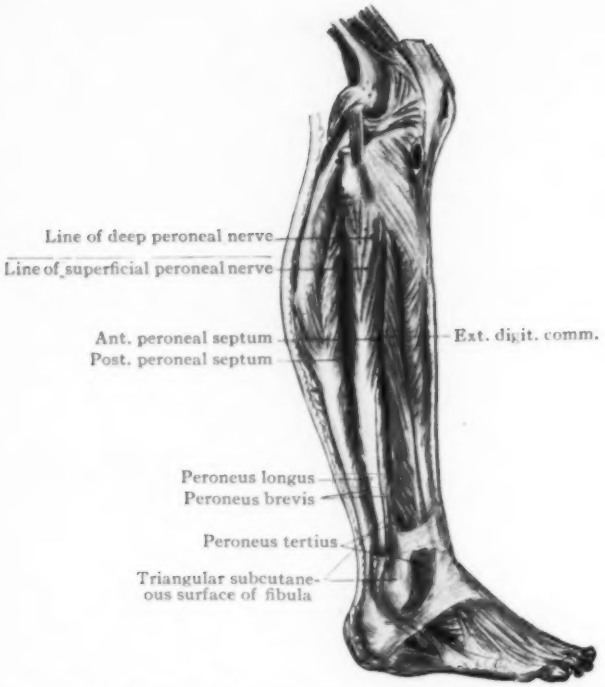
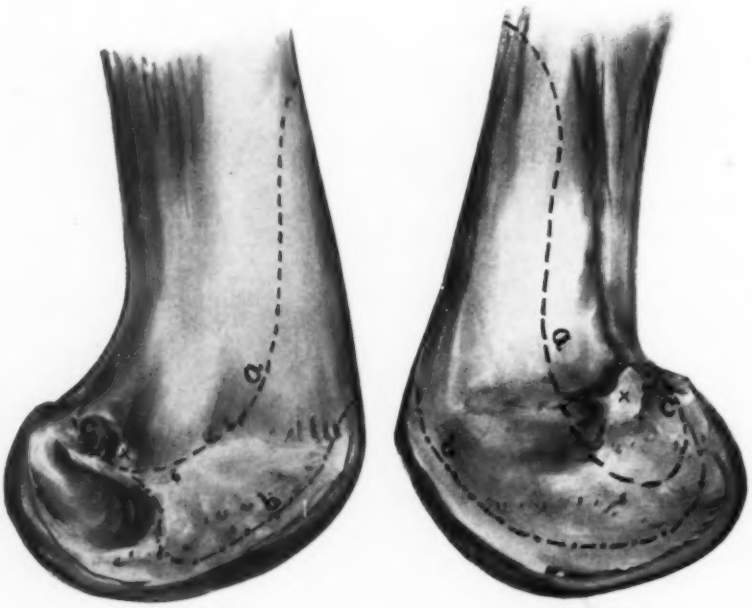


FIG. 18.—Represents a dissection of the muscles on the lateral aspect of the leg. It shows the triangular subcutaneous portion of the fibula at the lower part, and above this the peronei muscles covering the lateral surface of the fibula. The anterior and posterior peroneal septa are designated. The lines of the deep peroneal nerve in the substance of the peroneus longus, on its way to the front of the leg is shown by the upper oblique dotted line. That of the superficial peroneal nerve (musculocutaneous) in its intramuscular course is shown by the lower oblique dotted line.



Lateral surface Medial surface

FIG. 19.—Represents lateral views of the distal extremity of the right femur. Each epicondyle is shown by a cross. The line of attachment of the synovial membrane to the bone is shown by the dot-and-dash line *b*; the line of reflexion by the dotted line *a*. At *c* the two lines coincide and pass across the posterior aspect of the bone. On the lateral surface distal and posterior to the prominence of the epicondyle, a deep groove, from which the popliteus takes its origin, is clearly shown.

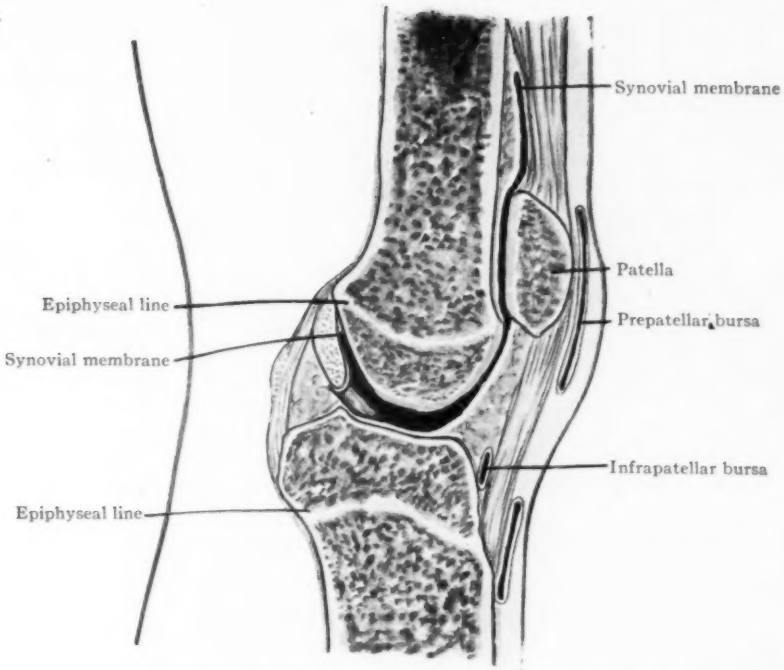


FIG. 20.—Represents a median sagittal section through the knee-joint. It shows the prolongation of the synovial membrane upward above the patella, and the anteroposterior relationships of the epiphyseal line to the knee-joint. In front the line is very close to the attachment of the synovial membrane; behind it is a short distance proximal to the joint. The epiphyseal line of the tibia is seen to be far removed from the joint cavity.

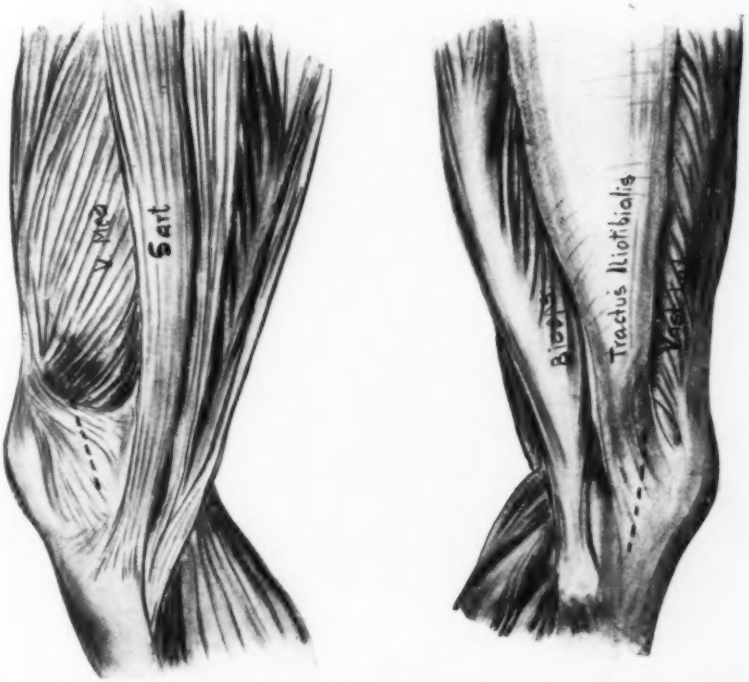


FIG. 21.—Represents a dissection of the muscles on the medial and lateral aspects of the lower end of the femur and knee-joint. The broken vertical lines show the incisions employed to expose the outer surfaces of the condyles and the lower end of the shaft. The lowest point corresponds to each epicondyle. Notice the respective levels of the vastus medialis and vastus lateralis. Notice also the solidity and strength of the tractus iliotibialis. (The vertical lines are not quite correct. The upper ends should be more posterior).

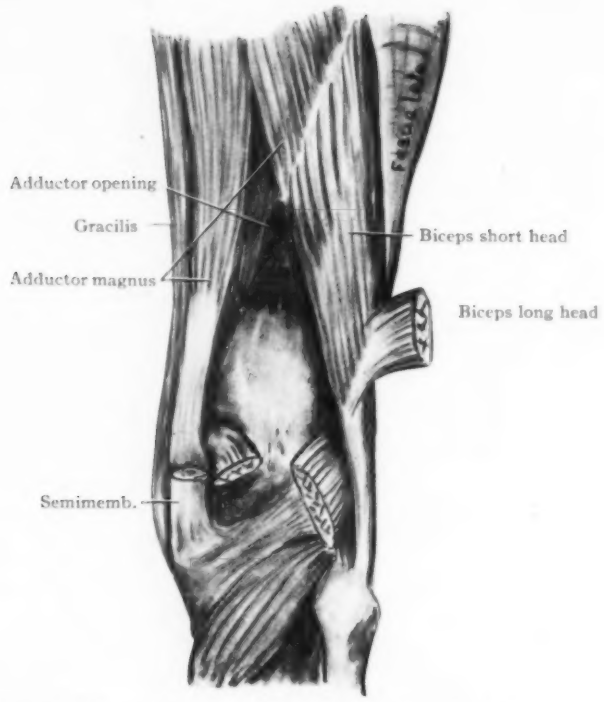


FIG. 22.—Represents a dissection of the deep muscles bounding the popliteal space. It is intended to show the method of access to the posterior surface of the femur lateral to the tendon of the adductor magnus. The adductor opening through which the femoral artery and vein pass is shown by a kite-shaped slit.

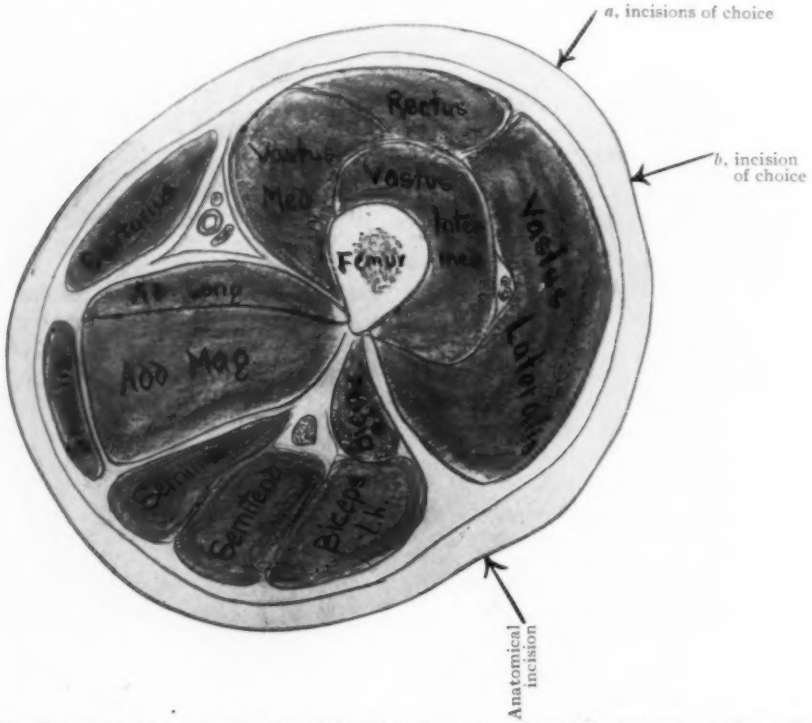


FIG. 23.—Represents a transverse section of the thigh about the middle of Hunter's canal. The shaft of the femur is seen to be deeply embedded in muscles. The incisions of choice are shown by the arrows marked *a* and *b*, the former passing between the rectus femoris and the vastus lateralis, the latter passing through the substance of the vastus lateralis. In either case the vastus intermedius will be divided before the bone is reached. The "anatomical incision" is shown by an arrow. It passes in this situation between the vastus lateralis and the short head of the biceps cruris. It is evident that this incision is excellently placed for drainage.

terior surface is covered by the tendons of the tibialis anterior, the extensor pollicis longus and the extensor digitorum communis as they course from the leg to the foot. The anterior ligament of the ankle-joint is attached along a groove just proximal to the articular surface. The *posterior surface* is covered by the tendons of the flexor pollicis longus, the flexor digitorum longus and the tibialis posterior as they pass to the sole of the foot. The last two structures pass in a groove (sulcus malleolaris) which runs along the posterior border of the malleolus (Fig. 15). The *lateral surface* is applied to the fibula over a triangular area to which strong fibres of the interosseous ligament are attached. Part of this area is often covered by cartilage and forms a part of the synovial cavity of the ankle-joint (Fig. 13). The *medial surface* is prolonged downward into the medial malleolus, the medial surface of which is subcutaneous. To its apex the strong deltoid ligament is attached. Along its posterior border there is a distinct broad oblique groove which accommodates the tendons of the tibialis posterior and the flexor digitorum communis (Fig. 15). The epiphyseal line is entirely outside the joint cavity (Fig. 13). The medial surface including the malleolus is subcutaneous and accessible. It is exposed frequently in open operations for fracture (Pott's fracture, separation of lower epiphysis, etc.) and in cases of osteomyelitis in the neighborhood of the epiphyseal line.

2. *The Shaft.*—The medial surface of the shaft of the tibia is subcutaneous from end to end except in its upper fourth, where the tendons of the sartorius, gracilis and semitendinosus overlap it (Fig. 14) as they pass to their insertions. It is the most accessible surface of the bone and for that reason operations on fractures and inflammatory foci are always conducted from this side. Areas of osteomyelitis in the upper end of the diaphysis can be reached by an incision placed between the insertions of the sartorius and the ligamentum patellæ. By peeling the insertions of these tendons from the bone and preserving the periosteum to which they are intimately attached large areas of diseased bone can be removed without jeopardizing the subsequent reproduction of the upper end of the shaft. The lower end of this surface passes distally into the medial malleolus which is also subcutaneous. The surface of the shaft proximal to the malleolus is frequently exposed in orthopædic operations. In cases of talipes valgus the tendon of the tibialis anterior is exposed, dislocated and fastened into a vertical groove made in the medial surface of the tibia (Galli). In cases of talipes equinus the same surface is pierced with a drill and artificial silk ligaments (Bartow, Bradford) or fascial strips are passed through the drill holes, the other ends being passed through the bones of the tarsus on their dorsal surfaces.

The lateral surface of the tibia is bounded in front by the anterior crest (shin) and behind by the interosseous crest. From its proximal two-thirds the tibialis anterior muscle arises. It is very deep and inaccessible and is on that account never exposed. In its distal third this surface passes to the front where it is easily accessible. No muscles arise from its surface, but over it the tendons of the tibialis anterior, the extensor hallucis longus and the extensor digitorum communis pass obliquely on their way to the foot. On it lie also the anterior tibial artery and the deep peroneal nerve. The artery and nerve lie in close contact with each other, the nerve being placed laterally. Both structures are deeply situated and lie in close contact with the periosteum. The tibialis anterior lies to the medial side of the artery. Just above the ankle-joint the artery is crossed superficially from the lateral to the medial side by the tendon of the extensor hallucis longus. The extensor digitorum longus lies to the lateral side of the vessel (Fig. 16). It would be possible to utilize this surface for tendon fixation in cases of paralytic toe drop in the following manner. A vertical incision is made along the lateral border of the tibialis anterior tendon. The ligamentum transversum cruris is incised and the extensor tendons exposed. The artery and nerve

will be found lying underneath the extensor hallucis longus. If the tendon of this muscle is retracted to the lateral side, the anterior tibial artery and nerve will be exposed lying on the lower end of the tibia. The artery and nerve can be retracted from side to side while a groove is made in the bone in which the distal ends of the tendons are fixed. Finally, the artery and nerve are put back in place between the tendons. It is found, however, that silk tendons and fascial transplants passed through drill holes in the subcutaneous inner surface of the lower end of the tibia above, and through the tarsal bones below, is a much better operation for toe drop.

The posterior surface of the shaft: Practically all of the upper three-quarters of this surface is covered by muscles which are attached to it (Fig. 15). They are the popliteus, soleus, flexor digitorum longus and the tibialis posterior. The large arterial foramen, along which passes the nutrient artery of the bone, is placed at the junction of upper and middle thirds of the bone in the area covered by the tibialis posterior. The popliteal vessels and the tibial nerve lie on the posterior surface of the popliteus muscle as far as its lower border. Distal to this point (where the popliteal divides into the anterior and posterior tibial branches) the posterior tibial artery and the tibial nerve lie on the posterior surface of the tibialis posterior muscle. The nerve lies lateral to the artery. Superimposed on the above-named structures lie the fleshy masses of the gastrocnemius and the soleus and the tendo Achillis. It will be evident that this surface of the bone should never be exposed deliberately. The *lower quarter* of this surface has no muscles arising from it or inserted into it. It is covered completely by the tendons of the tibialis posterior, flexor digitorum longus and the flexor hallucis longus (Fig. 15). Between the last two lie the posterior tibial artery and the tibial nerve. Both structures lie on the bone and the nerve is lateral to the artery. A short distance above the ankle-joint the tendon of the tibialis posterior slips medially between the tibia and the tendon of the flexor digitorum longus. It then passes downward under the ligamentum laciniatum in a groove on the back of the median malleolus invested in a special synovial sheath. Parallel to it and placed laterally in a special synovial sheath courses the flexor digitorum longus tendon. Lateral to this in order lie the posterior tibial artery and the tibial nerve. Lateral to these structures, enclosed in a special synovial sheath and lying in a special groove in the tibia, lies the tendon of the flexor hallucis longus. This tendon is deeply situated but can be recognized by the fleshy fibres which enter its lateral aspect almost as low down as the synovial sheath. This surface is of great surgical interest, inasmuch as it is frequently exposed by surgeons, for the purpose of implanting the distal end of the tendo Achillis into a groove made into the bone, for the relief of paralytic talipes calcaneus. After exposure and division of the tendo Achillis by an incision along its medial border, the deep fascia of the leg is divided medial to the flexor hallucis longus. The posterior tibial artery and nerve are retracted medially and the flexor hallucis longus laterally and the posterior surface of the bone exposed. After gouging a groove deep into its medullary cavity the distal end of the divided tendo Achillis is fixed in the cavity and the periosteum closed over it (Galli).

3. *The Proximal Extremity.—The* proximal end consists of the medial and lateral condyles (tuberosities), the intercondyloid eminence (spine), and the tuberosity (tubercle). This practically correponds to the whole upper epiphysis of the bone. The epiphyseal line is entirely extra-articular as regards the knee-joint. On its lateral aspect it passes through the cartilaginous area which forms the tibial part of the proximal tibiofibular joint (Fig. 17). On the medial side it is considerably distal to the knee-joint and reaches the surface of the bone in the substance of the tibial collateral ligament. Anteriorly it curves downward distal to the tubercle of the tibia. Posteriorly it reaches the surface considerably distal

to the attachment of the posterior ligament of the knee-joint (Fig. 20). The anterior and medial surfaces of the medial condyle are subcutaneous and accessible. The posterior surface is inaccessible, being occupied by the insertion of the semimembranous tendon and covered by the tendons of the sartorius, gracilis and semitendinosus. The lateral epicondyle is accessible in front of and proximal to the upper tibiofibular articulation. Behind this the tendon of the biceps and the common peroneal nerve are superficial to it. The tuberosity is accessible at its distal extremity below the attachment of the ligamentum patellæ (Fig. 14). Proximally, the ligamentum patellæ covers it and is separated from it by a bursa (Fig. 20).

THE FIBULA. — 1. *The Distal Extremity.* — The distal extremity of the fibula, or lateral malleolus, is of a pyramidal shape. It is situated on a plane posterior to and extends further toward the sole of the foot than the medial malleolus (Fig. 13). Its lateral surface is subcutaneous and is continuous with a triangular-shaped lateral surface on the lower part of the shaft. To the apex of the malleolus and to its anterior border are attached ligaments. Its posterior border shows a deep groove in which the tendons of the peroneus longus and brevis lie. The medial surface has a triangular articular area which articulates with the lateral surface of the talus. Behind this is a deep depression in which the posterior talofibular ligament is attached. The line of separation between the epiphysis and diaphysis corresponds to the level of the joint between the tibia and the talus. It communicates with the ankle-joint (Fig. 13). Above the epiphyseal line the lower end of the diaphysis is in contact with the synovial prolongation of the ankle-joint which lines the lower tibiofibular articulation. The whole of this part of the bone is accessible from its subcutaneous aspect. It is accessible in fractures of the external malleolus, in cases of tuberculous osteomyelitis and rare cases of acute osteomyelitis.

2. *Shaft.*—On the lateral surface of the distal extremity of the shaft of the fibula there is a triangular area bounded by two ridges which can be traced above into the anterior crest (Fig. 18). At the apex of this triangle the origins of the peroneous brevis and peroneus tertius diverge from one another. This is the most accessible portion of bone and it is quite frequently exposed in the open operative treatment of Pott's fracture. This surface passes below into the outer surface of the lateral malleolus. The posterior surface of the lateral malleolus is grooved deeply and contains the tendons of the peronei muscles, the longus being most superficial. The outer surface of this part of the bone is utilized for tendon fixation in cases of paralytic talipes varus. A deep groove is made in it and the peroneus longus dislocated and fastened firmly in the groove. The original peroneal groove on the posterior aspect is deepened and the peroneus brevis fixed in it.

The rest of the fibula is covered by muscles. From the medial surface (the part between the anterior and interosseous crests) arise the extensor digitorum communis, the peroneus tertius and the extensor hallucis longus. From the lateral surface (between the anterior and lateral crests) arise the peroneus longus (proximally) and the brevis (distally) muscles. From the posterior surface (between the lateral and interosseous crests) arise the soleus muscle (proximally) and the flexor hallucis longus (distally). Dipping down between these three groups of muscles are two strong intermuscular septa, which have firm attachments to their respective crests. The one which passes between the peroneus longus and brevis muscles, behind, and the extensor digitorum communis and peroneus tertius, in front, is called the "anterior peroneal septum." The other which passes between the peronei in front and the calf muscles (soleus and flexor hallucis longus) behind is called "the posterior peroneal septum" (Fig. 18). The superficial peroneal nerve lies in a sheath in the anterior peroneal septum after it pierces the fibres of the peroneus longus muscle. It becomes cutaneous in the distal third of the leg by piercing

the deep fascia. There is no structure in the way of approaching the bone along the posterior intermuscular septum which is therefore the route of choice. Blunt dissection behind the peronei will enable us to separate the muscular fibres from the septum until the crest of the bone is reached. In the upper third of the shaft the dissection will pass between the peroneus longus and the soleus. Care must be taken not to injure the deep peroneal nerve as it winds round the neck of the fibula in the substance of the peroneus longus muscle. Roughly, its position is about one inch below the most prominent part of the head of the fibula. In the middle third of the leg the dissection passes between the peroneus longus and the flexor hallucis longus.

3. *The Proximal Extremity.*—The proximal extremity of the fibula consists of the head (capitulum) which joins the shaft by a constricted portion called the neck. The head articulates by an area of triangular shape with the lateral condyle of the tibia. To the apex of the head is attached the short fibular collateral ligament and part of the tendon of the biceps. In front of the head there is a prominent tubercle from which the peroneus longus muscle arises. Behind the head is a tubercle from which the soleus muscle arises. A very narrow area of the bone is accessible between the attachments of these muscles and the attachment of the fibular collateral ligament. To expose the rest of the head and the neck of the bone the muscles attached to it must be elevated and retracted downward. The epiphyseal line is entirely extra-articular as regards the tibiofibular joint and is situated just below the expanded part of the head of the bone (Fig. 17). Great care must be taken in exposing the neck of the fibula not to injure the deep peroneal nerve.

The Femur.—1. *The Distal Extremity.*—By this we mean the epicondyles and condyles. The anterior, posterior and inferior surfaces of the medial and lateral condyles are covered with cartilage and lie inside the capsule of the knee-joint. The anterior and posterior cruciate ligaments are attached to the intercondyloid fossa, which is a deep space lying between the condyles posteriorly (Fig. 17). The patella lies in the groove between the condyles in front. It would be impossible to expose the bone from in front or behind without opening the joint cavity. The lateral aspect of each condyle is subcutaneous and on each there is a projection called the epicondyle (Fig. 19, +). The medial projects very prominently. It is capped by the adductor tubercle and to it are attached the fibres of the tibial collateral ligament of the knee-joint. It corresponds to the epiphyseal line. The lateral epicondyle is not so prominent. Just distal to its most prominent part the popliteus tendon lies in its bony groove; while just posterior to it is attached the fibular collateral ligament. The synovial membrane is attached to the femur all around the line of junction of bone and cartilage. The actual joint cavity, however, overlaps the lateral and anterior (Fig. 20) aspects of the bone to a large extent and makes it necessary for us to plan an incision *outside the line of reflexion* of the synovial membrane so as to peel it from its recesses and to uncover the bone. The lower surface of the shaft in front is covered by the upper part of the synovial cavity for quite a distance above the level of the upper border of the patella, but the synovial membrane can be peeled from this surface as low down as the cartilaginous margin without opening the joint cavity. Similarly on the lateral aspects of the condyle an area in front of each epicondyle is overlapped by the lateral recesses of the joint cavity. The drawings in Fig. 19 representing the lateral and medial aspects of the condyles show by dotted lines the actual line of attachment of the synovial membrane and its line of reflexion. The line of attachment is shown by the dotted line *b;* that of reflexion by the dotted line *a*. The line *c* represents the fusion of *a* and *b*.

The area proximal to and behind the dotted line showing the line of reflexion of the synovial membrane is absolutely safe for surgical approach. It will be seen that both lateral and medial epicondyles (shown by a cross) are outside

this area, and that there is a considerable area of bone above and behind these prominences, directly accessible. A vertical incision extending proximally from the epicondyles could be carried down to bone without risk of opening the knee-joint. On the medial side (Fig. 21), it would cut through the aponeurotic expansion passing from the vastus medialis to the side of the patella and at a higher level the vastus medialis muscle itself. On the lateral aspect it would split the iliotibial band of fascia lata tractus iliotibialis and also at a much higher level sever the fibres of the vastus lateralis. By peeling the deeper structures from the bone backward and forward a large area could be exposed for operative procedures. In front the reflexion of synovial membrane would be brushed away and there would be no danger of opening the articulation. This is the route of choice in osteomyelitis of the epiphysis and the lower end of the diaphysis. In fractures through the condyles and T-fractures, nails or screws can be inserted in this area.

2. *The Shaft.*—This is so closely and massively invested by muscles that it is only accessible to a slight extent by incisions which pass between the muscular masses.

The posterior surface: There is a triangular area on the posterior surface of the lower end of the shaft which is bare of muscular attachments (Fig. 22). It is bounded laterally by the attachment of the short head of the biceps and medially by the part of the adductor magnus descending to the adductor tubercle. It forms the floor of the popliteal space. Resting on this surface are the popliteal artery and vein and the upper geniculate vessels. This surface is accessible by a vertical incision along the line of the adductor magnus tendon. The deep dissection passes in front of the inner hamstrings which are retracted posteriorly. After exposure of the tendon of the adductor magnus, that structure is retracted forward. If the popliteal vessels are retracted laterally a considerable area of bone can be exposed. The incision is commonly used for ligature of the popliteal artery (Jobert). It has been employed by me a few times for the removal of sequestra from the lower end of the femur and for the dissection of synovial cysts from the popliteal space. In one case of osteomyelitis with a sequestrum partly within and partly without its involucrum, I detached the adductor magnus from the bone over a considerable area, retracting it proximally along with the femoral artery and vein. The rest of the posterior surface of the shaft is so closely invested with muscles (adductors, quadratus femoris, glutæus maximus and biceps cruris) over which lie the hamstrings and the great sciatic nerve that it may be considered as inaccessible.

The *antero-external surface* of the femur, by which we mean the surface between the insertions of the adductors (pectineus, adductor longus and brevis and adductor magnus) and the line of origin of the vastus lateralis, is covered by the vasti muscles as by a blanket (Fig. 23). The vastus intermedius covers it anteriorly and laterally in its lower three-quarters. The same muscle also covers the anterior aspect of the upper quarter. The vastus medialis covers the medial aspect of this surface from the spiral intertrochanteric line above as far as the upper border of the medial condyle below. The vastus intermedius is overlapped on its medial aspect by the vastus medialis from end to end. The free anterior or lateral border of the vastus medialis corresponds to a line running vertically upward along the middle of the front of the thigh. The lateral aspect of the vastus intermedius is overlapped by the vastus lateralis over the whole of its lower three-quarters. In the upper quarter the intermedius is no longer attached to the lateral aspect of the bone, and here the vastus lateralis invests the bone closely. Between the anterior margins of the vastus medialis and the vastus lateralis the rectus femoris is wedged. It lies on the anterior surface of the vastus intermedius. In the upper two-thirds of the thigh (Fig. 24) the rectus can be separated with ease from the vasti muscles. Fig. 23 represents a transverse section of the thigh

through the middle of the Hunter's canal and shows the manner in which the femur is invested. It will be seen that the femur cannot be exposed without dividing the fibres of the vastus intermedius. If the incision passes medial to the rectus femoris (a very undesirable route), it might be possible to separate the rectus femoris and the vastus medialis from one another. If the incision passes lateral to the rectus femoris, that muscle could be separated from the vastus lateralis (arrow *a*). In either case the vastus intermedius would require division before the bone could be exposed. As a matter of fact, the vastus lateralis cannot be separated to any great extent from the rectus femoris except in the lower third of thigh. The edges of the muscles fuse with one another at the junction of the upper three-fourths with the lower fourth and would require careful separation. At the level of the middle of the thigh the nerve trunks enter the vastus lateralis and bind it down. Careful examination of the point of entry of the nerves supplying the vastus lateralis shows that they spread out like the leaves of a fan. Those supplying the middle of the muscle enter it transversely, whereas those passing to the extreme ends are very oblique. A lateral vertical incision opposite the middle of the muscle would cut the nerves passing transversely but would not injure those passing obliquely to the upper and lower ends of the muscle. As the middle of the muscle is firmly held in place by its nerves, lesions of the middle third of the bone requiring a long incision would be better dealt with by a laterally placed vertical incision through the vastus lateralis. (The line of the incision is shown by the arrow *b* in Fig. 23.)

From the foregoing description of the anatomical arrangement of the muscles covering the shaft of the femur, we may conclude that the bone can be exposed safely by the following incisions:

(1) By an incision passing between the contiguous edges of the rectus femoris and the vastus lateralis, along a line drawn from the anterior superior spine to the lateral border of the patella. This route is available from a point just below the middle of the thigh (where the nerves enter the vastus lateralis) to the level of the upper limit of the synovial pouch of the knee-joint. After retraction of these muscles the vastus intermedius would be divided down to the bone (Fig. 23, *a*).

(2) By a vertical incision beginning at the lateral epicondyle and extending proximally parallel to the shaft of the bone. The distal fourth or third of the bone could be exposed by this route (see description of the distal end of the femur). Both vastus lateralis and vastus intermedius would be divided (Fig. 21).

(3) By an incision on the antero-external aspect of the thigh along a line drawn from the middle of the great trochanter to the outer border of the patella. This would be applicable to the upper two-thirds or even the upper three-quarters of the thigh. In its proximal fourth it would divide fascia lata and vastus lateralis only. In its distal half it would divide both vastus lateralis and vastus intermedius (Fig. 23, *b*). There is still another route by which the shaft of the bone can be reaced. namely, along the lateral intermuscular septum (arrow *C* in Fig. 23). The dissection would pass between the vastus lateralis and the short head of the biceps cruris distally, and the vastus lateralis and the insertion of the glutæus maximus proximally. It would expose the posterolateral aspect of the bone corresponding to the outer lip of the linea aspera, and its upper and outer and lower and outer branches. It is perfectly feasible in the dissecting room, but it has two serious drawbacks from a practical standpoint. First it would entail an incision on the posterior aspect of the thigh which would necessitate giving the anæsthetic in a prone position and would leave a wound difficult of access during convalescence, although placed in a satisfactory position as to drainage. Second, it would pass across the course of a number of branches from the perforating arteries on their way transversely across the femur to supply the vastus lateralis. It would be next to impossible to avoid injuring these vessels which would be hard to secure.

FIG. 24.—Represents a dissection of the muscles on the anterior surface of the femur. At the upper end, the dissection has been carried deeply so as to show the steps of an operation to expose the upper end of the femur below the anterior intratrochanteric line and a part of the capsule of the joint distal and lateral to the iliacus muscle. The ascending branch of the lateral circumflex artery is seen crossing the deep part of the wound. The interval between the rectus femoris and vastus lateralis is well shown. The nerve supply to the vastus lateralis enters its medial surface near the edge at the level of the middle of the thigh. The nerves are not shown in the figure (original dissection).

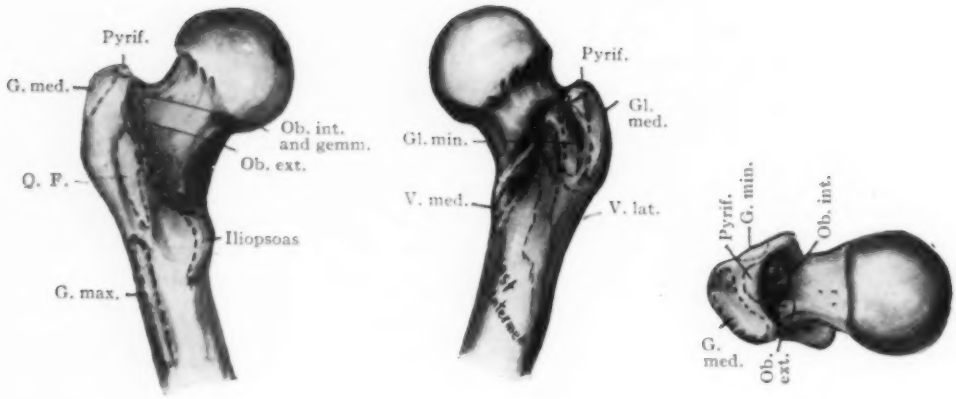


FIG. 25.—Represents three views of the proximal end of the femur. *A* is a posterior view. In it the crista intertrochanterica stands out in relief. *B* is an anterior view. Note the anterior intertrochanteric line which corresponds to that of the reflexion of the synovial membrane. Also note the clustering of the attachments of the vasti and glutæus minimus on the part of the shaft distal to this line. The area of bone distal and medial to the insertion of the glutæus minimus insertion is exposed in the treatment of osteomyelitis of the upper end of the diaphysis. *C* is a view of the upper aspect of the head, neck and trochanter.

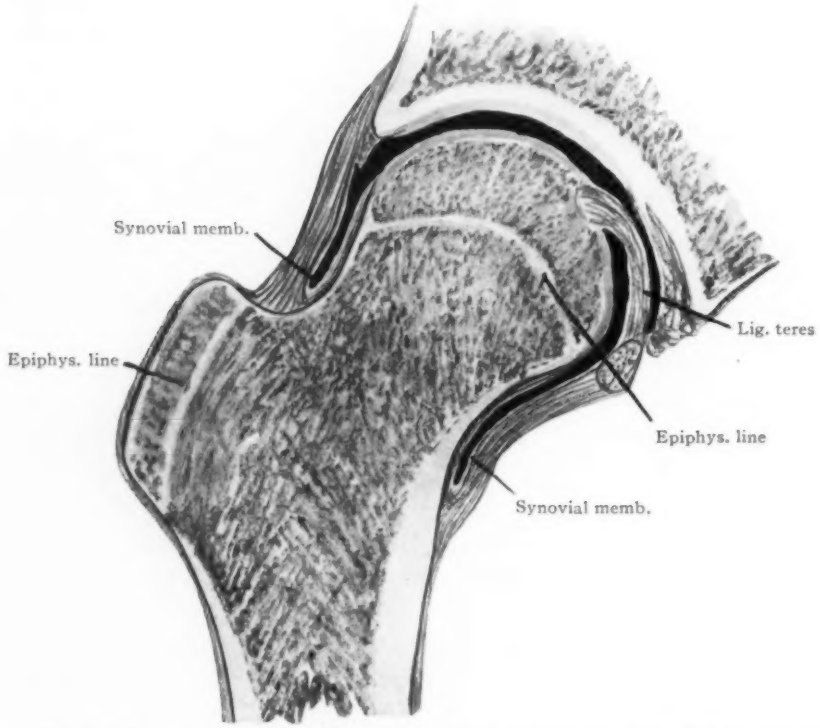


FIG. 26.—Represents a section through the acetabulum and hip-joint. The outline of the joint cavity is clearly shown. The epiphysis of the head is seen to lie entirely within, that of the greater trochanter entirely without the joint. The neck of the femur is seen to be continuous with the shaft. The epiphysis of the lesser trochanter is not shown.

3. *Proximal Extremity.*—The proximal extremity of the femur consists of the head, neck and the trochanters. The entire head and the greater part of the neck are within the capsule of the hip-joint. The synovial membrane is reflected on to the anterior surface of the neck at the level of the linea intertrochanterica; on the posterior surface of the neck the line of reflection is about midway between the crista intertrochanterica and the margin of the head. Thus almost all the anterior surface of the neck is intracapsular but only the proximal half of the posterior surface. The epiphysis of the head rests like a cap on the upper extremity of the neck. It is entirely within the capsule of the hip-joint (Fig. 25). The epiphysis of the great trochanter lies on the upper and outer surface of the shaft. It is entirely extracapsular. A third epiphysis is seen in the small trochanter. During the growth of the shaft the neck of the bone develops in an upward direction, and carrying the head on its apex thrusts itself between the centres of ossification of the great and lesser trochanter. A study of the different views of the proximal end of the femur in Fig. 26 will show the muscular insertions around the line of the synovial reflexion and attachment of capsular ligament. It will be seen that every surface of the head and neck is closely invested by muscles which arise from the pelvis and pass over the joint on the way to their insertions into the trochanters and the contiguous parts of the shaft of the femur.

The outer surface of the great trochanter is the most accessible part. It can be exposed by a vertical incision through the strong fascia lata into which the glutæus maximus is inserted. If the fascial edges are retracted the bursa between the glutæus maximus and the side of the trochanter is opened and the whole outer surface of the trochanter exposed. If the vertical incision is carried down to bone it will divide the insertion of the glutæus medius at its upper part and the origin of the vastus lateralis below. By peeling these muscles off the bone the whole outer surface of the trochanter major and the upper part of the shaft can be exposed (Fig. 26, *B*).

The posterior surface of the neck is so deeply situated as to be practically inaccessible. A study of the posterior aspect of the bone in Fig. 26 *A* will show that it is covered closely by the pyriformis, both obturators, the gemelli and the quadratus femoris. Superficial to these muscles the fleshy mass of the glutæus maximus lies. Anatomically it could be exposed by splitting the fibres of the glutæus maximus along the line of an incision passing from the posterior inferior spine of the ileum to the upper part of the trochanter major, and thence downward through the fascia lata for about two inches. After retracting the edges of the glutæus maximus the sciatic nerve would come into view as it passed distally over the obturator internus, the gemelli, obturator externus and the quadratus femoris. The pyriformis muscle, from under cover of which the sciatic nerve emerges, would serve as a rallying point. By retracting this muscle upwards and the gemelli downwards or better still separating them from their insertions and peeling them towards their origins the posterior aspect of the neck of the femur could be exposed. The whole procedure is very difficult and the route has little to recommend it. The *anterior surface of the neck of the femur* and that of the trochanter major can be studied in Fig. 26 *B*. The glutæus minimus is attached to a large area on the anterior surface of the great trochanter, but as the muscle sweeps from the back to reach its insertion, only a small portion of it lies on the anterior part of the capsule of the hip-joint. The front of the capsule is covered by the iliopsoas, the lateral edge of which (iliacus) lies practically parallel with the anterior intertrochanteric line. The contiguous edges of the glutæus minimus and the iliacus are not in contact as often stated. A triangular interval exists between them with its apex at the insertion of the glutæus minimus and its base above and lateral. The joint can be opened with safety in this interval by cutting through the anterior part of the capsule along the lateral border of the iliacus. If it is necessary to

expose the anterior surface of the shaft of the femur below this point the origins of the vastus lateralis, vastus medialis and vastus intermedius can be peeled from the bone. This region can be exposed by an incision from in front, which has been used frequently under various names (Barker's, Lücke's, Hueter's, Anterior incision) for drainage and excision of the hip-joint. It is almost perfect from an anatomical and physiological standpoint. It passes between muscles without dividing them and passes between the muscles supplied by the glutæal nerve (sacral plexus) and those supplied by the femoral (lumbar plexus). It gives by far the most extensive exposure of the diseased area in cases of acute osteomyelitis of the upper end of the shaft of the femur.

The steps of the dissection are as follows (Fig. 24):

The external incision (the anterior oblique) begins at the anterior superior spine of the ilium and passes downwards and medially parallel with the lateral border of the sartorius muscle. The deep fascia is opened between the sartorius and the tensor fasciæ latæ. The sartorius is retracted medially and the tensor laterally. The rectus femoris now comes into view. This is retracted to the medial side. The following structures are now exposed: At the upper end of the wound the iliacus muscle medially and the glutæus medius laterally. If the glutæus medius be retracted laterally the insertion of the glutæus minimus comes into view. Between the minimus and iliacus there is a triangular interval filled with fat. Distal to the insertion of the glutæus minimus lies the upper part of the origin of the vastus lateralis and internal to this the vastus intermedius and medialus (Fig. 26, *B*). Crossing the vasti somewhat obliquely is a branch of the lateral circumflex artery. This is often seen as a large trunk which divides at about the level of the base of the trochanter into (1) an ascending branch which passes over the vastus lateralis and enters the borders of the glutæi muscles, and (2) a transverse branch which runs over the vastus intermedius and ends under cover of the vastus lateralis which it supplies. The main arterial trunk or its branches should be retracted or ligatured and divided. If the hip-joint is to be opened and explored, the capsule is divided along the lower and lateral border of the iliacus muscle, between it and the glutæus minimus. If, on the other hand, the object is to reach the upper end of the shaft and to remove disease from the neck of the femur without opening the hip-joint the origin of the vasti are peeled off the bone to the desired extent and the insertion of the glutæus minimus detached to obtain sufficient room. The dissection in Fig. 24 will fully repay careful study.

RECAPITULATION OF ROUTES OF CHOICE

The Tibia.—(1) The route of choice is along the line of its subcutaneous surface from the medial tuberosity proximally to the tip of the medial malleolus distally.

(2) Along the line of the medial border of the tendo Achillis and the flexor pollicis longus to expose the posterior surface of the distal end of the shaft for tendon implantation and fixation.

(3) Along the line of the lateral border of the tibialis anterior to expose the anterior surface of the distal end of the shaft for tendon implantation and fixation.

The Fibula.—(1) Along the line of the subcutaneous surface of the lower fourth of the shaft and the lateral malleolus.

(2) Along the posterior peroneal septum for the upper three-quarters of the shaft.

The Femur.—(1) Vertically upwards from either lateral or medial epicondyle for the lower epiphysis and the lower quarter of the shaft.

(2) An anterolateral incision lateral to the rectus femoris for a small area at the junction of the middle and lower thirds of the shaft.

(3) An external incision for the upper three-quarters of the shaft along a line drawn from the tip of the trochanter major to the outer border of the patella.

(4) Between the vastus lateralis in front and the short head of the biceps cruris and the insertion of the glutæus maximus behind, along a line extending from the posterior border of the great trochanter proximally to the posterior border of the lateral condyle distally (*c*, Fig. 23).

(5) Along the line of a medial incision extending vertically upwards from the adductor tubercle, to expose the posterior surface of the lower fourth of the shaft (popliteal surface).

(6) The anterior oblique incision lateral to the line of the upper end of the sartorius muscle for the exposure of the hip-joint, the neck of the femur and the upper part of shaft.

LENGTHENING OF THE TENDO ACHILLIS IN THE TREATMENT OF COMPLICATED POTT'S FRACTURE*

By Charles N. Dowd, M.D.

of New York

Major, M. C.; Attending Surgeon to the Roosevelt Hospital

Without doubt, the ordinary results from the treatment of Pott's fracture are reasonably good. Occasionally, however, one sees a patient who emerges from his primary treatment with distressing disability. The backward and outward displacement of the tarsus, the separation of the malleoli, and the eversion of the foot, one or all, produce very disturbing loss of function.

Recently, soon after the study of two such cases, the writer was surprised at his inability to maintain correct reposition of the fragments in what seemed to be an ordinary Pott's fracture. The patient, a man of forty, received his treatment, under anæsthesia, only four hours after falling and sustaining a Pott's fracture (Roosevelt Hospital, History A 9649, December 28, 1917). Reduction of the deformity was easy, although there was much swelling, and extreme dorsal flexion was not practicable. The tarsus was pushed well forward and the foot slightly inverted and held at an angle of 90 degrees with the leg. A firmly fitting plaster-of-Paris dressing was then applied.

The next day an X-ray picture showed that the reposition had not been maintained, but that the tarsus was displaced backward. It also showed a longitudinal split in the lower end of the tibia with wide separation of the fragments (see Fig. 1).

This longitudinal split in the lower end of the tibia is not mentioned in the ordinary treatises on Pott's fracture, but its existence in this and in the following case show that it is one of the conditions which must be borne in mind. It explained the difficulty in maintaining apposition. The articular surface of the tibia was so shattered that it presented no satisfactory obstacle to the upward and backward displacement of the tarsus under the pull of the calf muscles.

On January 1, anæsthesia was again given in the expectation of lengthening the tendo achillis. However, correct position was easily obtained, and, since the swelling had subsided, it was believed possible to maintain the corrected position by plaster, hence a closely fitting plaster dressing was again applied and the tendon was not then cut.

This was an error. On the following day the X-ray showed the position worse than ever (see Fig. 2). It was manifestly necessary to remove the displacing factor—the pull of the calf muscles. The writer had recently seen the deformity of Pott's fracture reproduced under the tension of the calf muscles while a patient was struggling

*Read before the American Surgical Association, June 7, 1918.

FIG. 1.—Comminuted Pott's fracture, showing posterior displacement of tarsus after deformity had been reduced under anæsthesia and after a firm plaster-of-Paris dressing had been applied.

FIG. 2.—Comminuted Pott's fracture, showing posterior displacement of tarsus after second attempt at reduction under anæsthesia and application of plaster.

FIG. 3.—Improved position of tarsus after lengthening the tendo achillis and reapplication of plaster.

FIG. 4.—Posterior view taken at same time as Fig. 3.

FIG. 5.—Comminuted Pott's fracture held in good position after lengthening of tendo achillis and application of plaster.

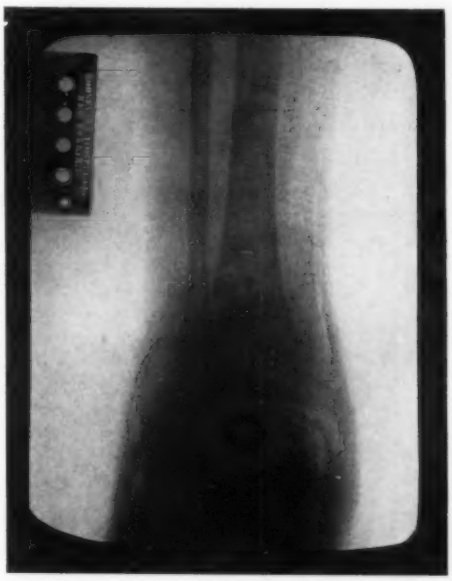


FIG. 6.—Posterior view of Fig. 5.

FIG. 7.—Same case as Figs. 5 and 6, four months later.

FIG. 8.—Same case as Figs. 5, 6 and 7, four months later (posterior view).

in the early stages of anæsthesia. When he was quiet the foot was easily put in correct position, but when he struggled the tension of the calf muscles reproduced the deformity in spite of strong efforts to prevent their doing so. It was a vivid demonstration of the action of these muscles in producing this deformity.

The tendon was, therefore, lengthened by the method of Hibbs, and molded plaster splints were applied. Dr. James M. Hitzrot, who was present in consultation, approved the procedure after endeavoring to maintain the position with the knee flexed.

The later notes are as follows: Patient left the hospital January 24, with foot in excellent position, as shown by inspection and by X-ray (see Figs. 3 and 4). He walked with crutches, foot in plaster; weight bearing forbidden.

February 15: Plaster removed. Position of foot and ankle excellent. Still unable to plantar flex foot. Slight weight bearing allowed.

February 21: Calf muscles beginning to work satisfactorily. Tendon shows good formation. Position of foot good. Slight swelling present.

March 4: Good position of foot and ankle. Bears weight on foot. Calf muscles contracting well. Ankle motion 80 to 100 degrees.

He improved steadily, resumed his business early in March, using crutches. On June 3, motion in ankle was 80 to 105 degrees. Tendo achillis strong. Calf muscles somewhat atrophied but contracting well and gaining strength steadily. Walks much. Still slight limp. Does not use crutches. The position of foot is excellent. The malleoli seem normal and are the normal distance apart.

A second similar case was seen January 9, 1918 (Roosevelt Hospital, History A 9706). A traffic policeman of very strong build, who fell on the ice and sustained a Pott's fracture. The X-ray showed a longitudinal splitting of the lower end of the tibia (Fig. 5) and his calf muscles were particularly strong, hence the tendo achillis was lengthened at the time of the first anæsthesia and molded plaster applied. The corrected position was maintained as shown by inspection and by X-ray plates (see Figs. 7 and 8). The progress corresponded to the progress of the first case in all essential details. He was put on limited police duty in two and one-half months and gained steadily in strength and in function.

He was seen on May 27th. Walked with a very slight limp. Motion in foot 75 to 110 degrees. Tendo achillis very strong and well developed. Calf muscles contracting satisfactorily. Conformation of ankle-joint and position of malleoli and of foot seems normal. Firm on his feet and expects to resume his regular duties as traffic policeman before the summer is past.

Hibbs[1] has had large experience in the lengthening of the tendo achillis for "muscle-bound feet." He assures a return to normal muscle function

[1] Russell A. Hibbs: N. Y. Med. Jour., July 19, 1902; N. Y. Med. Jour., May 2, 1903; N. Y. Med. Jour., October 24, 1914.

in adults in four to six months "with absolutely no danger of any impairment of the strength of the tendon or the function of the muscle."

I do not find that the procedure has been much used in the treatment of Pott's fracture, but Robert Jones[2] advocates tenotomy of the tendo achillis in those instances where the tarsus is displaced forward and in the equinus deformity which sometimes follows badly healed Pott's fractures.

Guichard[3] favorably records the treatment of four cases of Pott's fracture by the aid of tenotomy, in 1902.

Manifestly, the procedure is not to be advocated in those instances where proper position of the fragments can be maintained without it, but it certainly should be used in those instances where such position cannot be maintained, especially if there is a longitudinal split of the lower end of the tibia. Also, X-ray pictures should be repeatedly taken to ascertain whether plaster maintains the position and whether a longitudinal split exists.

In military surgery the frequent transfer of patients from one surgeon or hospital to another and the fact that so many soldiers are strong and muscular lead one to be particularly careful that bad position is not accepted when good position can so easily be secured by so simple a procedure.

The period of treatment does not differ, materially, from the $4^{2}/_{10}$ months, which Estes has stated as the term to be expected after fractures of the lower part of the leg.

It is also to be remembered that the molded plaster splints of Stimson give more security than a circular plaster encasement.

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[2] Robert Jones: Injuries to Joints, p. 174, London, 1917. Notes on Pott's Fracture, Liverpool Medico-Chirurgical Journal, 1887, p. 265.

[3] Guichard, Ch. A.: Thèse de Paris, 1902, De la Tenotomie du Tendon d'Achille dans les Fractures de Jambes.

RECEIVING AND OPERATING PAVILIONS FOR A MODERN BASE HOSPITAL*

By Astley P. C. Ashhurst
of Philadelphia
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It is the purpose of this communication to describe the adaptation of standard barrack buildings to the uses of receiving, bathing, operating, and X-ray pavilions in a Base Hospital. The buildings described form part of Base Hospital 34, American Expeditionary Forces, which is situated in the outskirts of a large city, at a considerable distance from the front.

It is believed that the use of barrack buildings for these purposes has distinct advantages even when buildings of permanent construction are available. In the case of Base Hospital 34 there is a large, new, modern building of stone and reinforced concrete, which accommodates in itself 1100 beds. It would have been quite possible to have utilized rooms in this building for receiving, bathing, operating, and X-ray departments; but I believe that no building originally constructed for other than hospital purposes will lend itself so admirably as do these barrack buildings to the purposes indicated, since only the four outer walls limit the arrangement of the interior.

The barrack buildings employed at Base Hospital 34 are of what is known as the Fender type, from the name of the manufacturer. The "life" of those buildings is said to be from three to seven years, without noteworthy repairs. They are composed of uniform wooden panels, each two metres in width and two and a half metres high, made of two thicknesses of wood, with an intervening air space of 7.5 cm. Each panel, technically speaking, includes the opposite sides of the oblong rectangular building, with the corresponding sections of roof and floor. The roof also is of two layers of wood, separated by an air space, and is covered on the outside with tarred paper. It rises to a peak four metres high and is ventilated about half-way up the slant.

The buildings may be made of any desired length, but are all of uniform width of six metres. Those in use for various purposes at Base Hospital 34 vary from one, which is only 6 panels long (baths for enlisted personnel), up to a number which are 23 panels in length (about 150 feet). These latter serve as wards, with accommodations each for 50 beds.

The rapidity of construction is remarkable. The panels fit together with surprising accuracy, and are fastened by bolts. The enlisted men of the Medical Department, attached to our Hospital, learned the mechanism from the French within a very short time, and succeeded in erecting several

* Recommended for publication by the Chief Surgeon, American Expeditionary Forces.

15-panel barracks in an average time of one and a half to two days each. This, however, does not include the time necessary to prepare piers for the floors, which may demand two or three days preliminary work. The piers are made just high enough to bring the buildings level, and their use thus does away with the necessity of grading the ground. If cement floors are employed grading is necessary, and there is also the delay required for the cement to set. But if all the materials are at hand, it should not require more than two weeks to construct one of these pavilions.

The four barrack buildings about to be described are placed in a large level courtyard formed by the three wings of the central building of Base Hospital 34. They are of uniform dimensions—6 by 30 metres. The building nearest the entrance road is the Receiving Ward; adjoining this, and connected with it by a covered passage, is the Bathing Pavilion. Parallel with these, but 6 metres distant, is the Operating Pavilion, while close to this (3 metres distant) is placed the pavilion devoted to X-ray Laboratories and to dressing rooms for surgeons and for nurses, and a room for the manufacture of surgical dressings. The relations of these buildings are shown in the accompanying plot plan (Fig. 1).

The floor of the Receiving Pavilion is of wood; that of the other three buildings is of cement, which is relatively abundant in France, and which certainly makes much more suitable flooring for bathing and operating rooms than does wood. All four buildings are heated from the central plant (hot water).

As designed by the manufacturers, each alternate panel contains a large window, the intervening panels having small windows placed 2.75 metres from the floor. But as the panels are interchangeable, it was possible in constructing the Operating Pavilion to place all the large windows on the same side, while beneath the small high windows thus coming to occupy the opposite side of the building, all plumbing fixtures were conveniently located. A similar arrangement in the Bathing Pavilion afforded accommodations along the rear wall for a row of shower baths. The floors of the Bathing and Operating Pavilions are constructed with a broad shallow gutter along one side, thus facilitating cleaning and drainage. Owing to the solidity of the floors it was possible to construct all partitions of tile and plaster. The interior of the buildings is painted, that of the Operating Pavilion being tinted a very pale green. This, with four skylights, gives ample daylight. Artificial light is electric; and gas has been introduced for emergency use.

Admission of Patients.—The incoming ambulances drive up from the east side, and back against the obliquely placed platforms to discharge their loads. By being placed thus obliquely in the road, a clear passage-way is left for other traffic beyond the ambulances; and the ambulances are enabled to continue on their journey westward, after discharge, without the additional backing manœuvres which would be required if the ambulance bodies were stationed at right angles with the road when discharging.

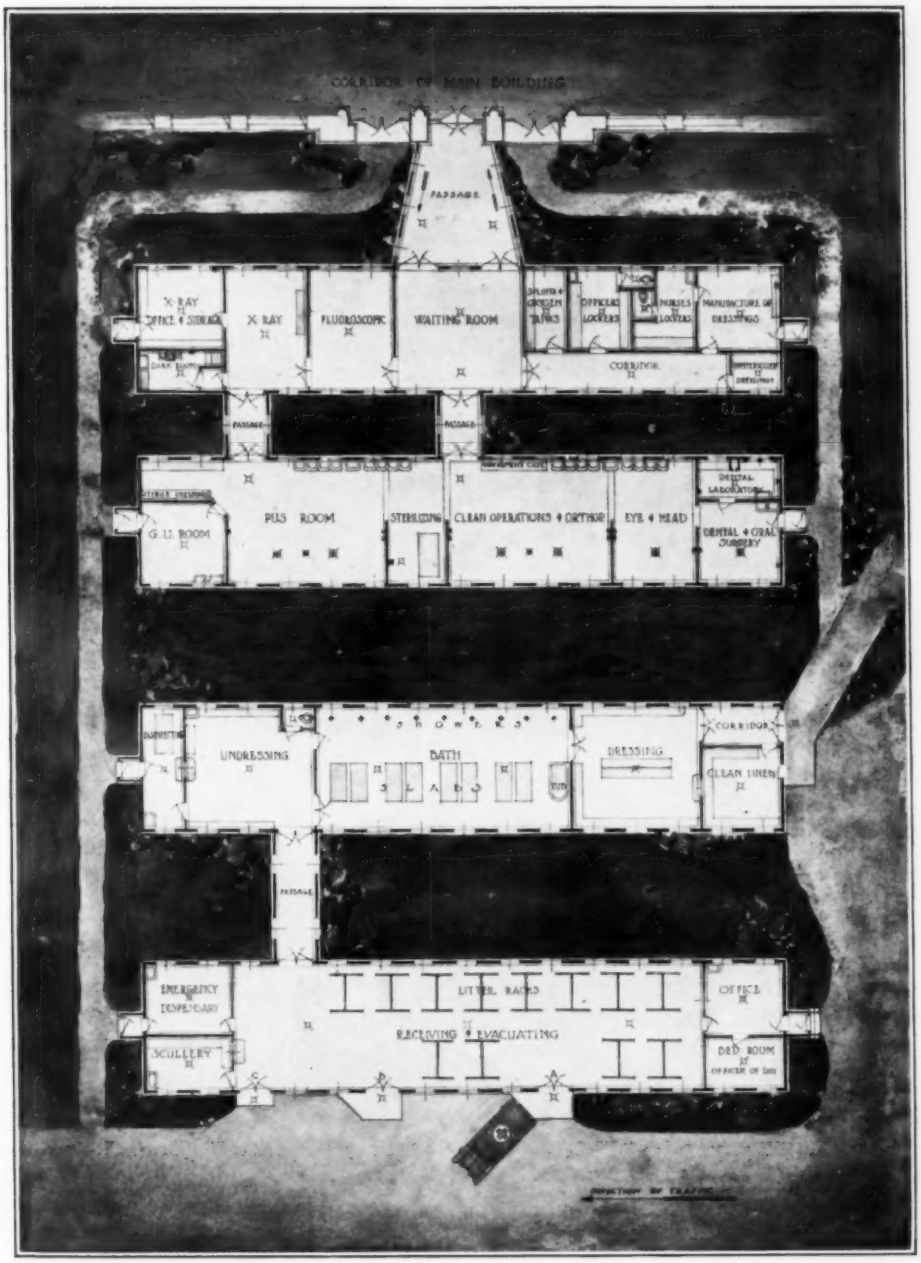

FIG. 1.—Court Buildings, Base Hospital 34, U. S. A., American Expeditionary Forces. (Scale, 1 centimetre = 1 metre.)

The patients on litters are carried, and ambulatory patients walk directly into the receiving ward, through doors *A* and *B*, where the litters are placed on racks. The litter bearers at once rejoin their ambulances, passing out by door *C* and carrying with them fresh litters. Attached to the receiving ward are the office of the officer of the day, as well as his bedroom; at the other end of the ward is a scullery, from which hot coffee may be served, and a minor operating room, in which patients may be catheterized, their dressings temporarily re-arranged, and intravenous saline infusions administered. The following regulations are in force:

"A waterproof tag will be attached to the wrist or neck of every patient as soon as he enters the receiving ward. On this tag will be noted the patient's name, the tentative diagnosis, and the ward to which he is assigned. *After* these data have been thus attached to the patient, the diagnosis tags which accompany him from his last station will be removed and from them will be made the necessary records (Forms 52, 55a, and 71, MMD).

"After such emergency treatment as required (scullery and minor operating room), the patient will be removed to the bathing pavilion by attendants coming thence.

"In the undressing room he will be completely unclothed; only such surgical dressings as are indispensable and the patient's waterproof tag will be retained. His soiled clothes will be listed in duplicate (Form 75, MMD), will be tied loosely in a bundle, the bundle will be tagged (Form 76, MMD), and it will be passed through the window into the disinfecting room. After disinfection they will be turned over to the non-commissioned officer in charge of the storeroom for patients' effects.

"The naked patient will be carried by attendants from the undressing room into the bath room. Patients who can walk may take shower baths. Other patients will be placed on the washing slabs, where they will be thoroughly cleansed with soap and hot water. The hair of the head of all patients, and that of their bodies when necessary, will be closely cropped or shaved. After being dried helpless patients will be carried into the dressing room by clean attendants from that room. The bath attendants will carry patients neither into nor out of the bath room.

"In the dressing room the patients will be given hospital bed clothing, and will be carried to the proper ward by ward attendants. On leaving the dressing room the non-commissioned officer from the receiving ward will see that Form 55a (the "Clinical Brief" of the history) is attached to the proper patient, using the waterproof tag for identification."

The clothing of incoming patients is disinfected in a steam sterilizer, adjacent to the undressing room in the bathing pavilion. The washing of the patients is much facilitated by the use of slabs instead of bathtubs, though one tub is provided. These slabs are of slate, draining to a deep gutter on all sides, and the gutter draining at the foot of the table, the frame of which is constructed of iron piping. It is only when they are placed on the washing slabs that the patients are first moved from the litters on which they have been transported. The soiled litters are cleaned, and are carried back into the receiving ward when the attendants in the undressing room make one of their trips into that ward for other patients.

The Operating and X-ray Pavilions.—These are only three metres apart, and being joined by two wide passages form almost one continuous building. They are approached through a wide covered passage-way leading from

a recovery room in the centre of the main building. Opening out of this recovery room are two surgical wards, with accommodations for 75 beds; while a barrack ward of 50 bed capacity is accessible only three metres distant on the other side of the main building. Thus there are available, on the ground level, 125 beds for patients recently subjected to operation, where they may be kept until it is safe for them to be removed to more distant wards.

In the X-ray department are fluoroscopic and radiographic rooms, an office, and the darkroom. These rooms connect by a short wide passage with the operating rooms.

The other end of this X-ray pavilion is devoted to dressing rooms for surgeons and nurses, and a room for the preparation of dressings for sterilization. As the dressings come to us already made, through the intermediary of the Red Cross, it is necessary for our nurses only to sort the ready-made dressings into packages suitable for sterilization. Until they are needed for sterilization the dressings are stored in a closet next the nurses' work room. There is also a large closet for storage of blankets, splints, oxygen tanks, plaster of Paris, etc.

There are several well-lighted rooms available for purposes of anesthetizing patients: this may be done in the wide passage-way leading from the recovery room to the waiting room, in the waiting room itself (when not otherwise occupied), in the corridor to the east of the waiting room, or in one of the operating alcoves not in actual use.

In the operating pavilion proper there are accommodations for seven simultaneous operations—a limit which is not likely to be often exceeded. Specifically there are accommodations for oral surgery, including dental operations, with a well-appointed dental laboratory for manufacture of prostheses immediately adjacent; an alcove for head surgery in general, including also the eye, ear, nose, and throat; an alcove to accommodate two tables for orthopedic and other aseptic operations; another accommodating two tables for septic cases and a room for genito-urinary surgery. The steam sterilizing apparatus is placed near the centre of the pavilion, and ample accommodations are provided for storing sterile dressings near at hand.

In planning this operating pavilion it was determined to attempt a happy medium between the grand saloon type of operating room, where there are no partitions whatever, and the type where each operating table has its special room. The latter plan lacks economy in administration, many more attendants are required, and time and labor is lost by walking around so many corners instead of going directly to the place desired. The former plan, where numerous operators work simultaneously in the same large room, does not always tend to quiet and discipline, and injurious draughts may arise. By employing partitions 3 metres long (which reach half across a barrack building of this type), it was possible to form alcoves of sufficient depth to afford relative isolation for the operating teams; and by arranging that the two alcoves in most constant use should each be of sufficient size to accommodate two tables when necessary, it became possible

to reduce to the minimum the number of attendants required, as one sterile-handed nurse may easily conduct a suture table for two simultaneous operations.

My thanks are due to many members of our professional staff for suggestions of value in connection with the construction of these buildings, and especially to the Chief Engineer Officer, Major Fowler, for procuring material and giving us opportunity to use it as we deemed best. I have also to express indebtedness to Corporal Hoke and Private Stern, for their architectural knowledge and for drawing numerous plans.

THE TREATMENT OF MALIGNANT PERITONITIS OF OVARIAN ORIGIN*

By Ernest A. Codman, M.D.
of Boston, Mass.

An exceptionally fortunate series of cases of the kind implied in the above title has attracted me to this subject. I trust that the observations I have made are of importance enough to report to this Society. I may be able to stimulate your interest in looking up the end results in similar cases, and I may be able to give you hope for the hopeless.

All surgeons of experience know the type of case I mean. Clinically we find a large abdominal tumor, usually obscured by ascites and distention, and probably not more accurately diagnosed than as a case for exploratory laparotomy. On opening the abdomen there is a gush of straw-colored or blood-stained fluid. An irregular cystic mass adherent to the intestines and pelvic structures, and obscuring the accustomed landmarks, is found. Further exploration shows metastases in the omentum and peritoneum. If the operator is of a radical disposition he breaks down the adhesions, reams out cystic and solid masses of tissue, makes a bloody and disgusting mess and backs out, knowing that he has left portions of the tumor. Experienced surgeons probably back out sooner. The pathologist reports "cancer," and confuses us with his favorite nomenclature of ovarian tumors. We send sad messages to the friends, and feel some sympathy for the attending practitioner who must see the patient through the terminal stages of the disease.

My hobby for looking up end results has led me to some pleasant surprises in this type of case, for I find 5 cases still alive after periods of sixteen, eight, three, two, and one year respectively. Nature has been in the main responsible for these miracles, but I believe that certain principles of treatment have helped.

This is not an essay on the pathology of ovarian tumors. I simply speak of the clinical picture which we all know, whether the type be papillary, colloid or true adenocarcinoma. If you wish a pathologic classification, the best I know is that of Gebhard. From the literature we learn that the colloid form is less malignant than the papillary form and the latter is less malignant than the true adenocarcinoma. In searching the literature it is easy to find references to "the well-known fact" that papillary peritoneal metastases may disappear, but I have been unable to find definite reports of such cases, nor even the original authority for the statement. Bland-Sutton says: "It has been clearly established that when the abdomen has been opened for the removal of a papillomatous cyst, the peritoneum has been found studded with warts. A few years later the abdomen has been opened and all the peritoneal warts have disappeared."

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*Read before the American Surgical Association, June 8, 1918.

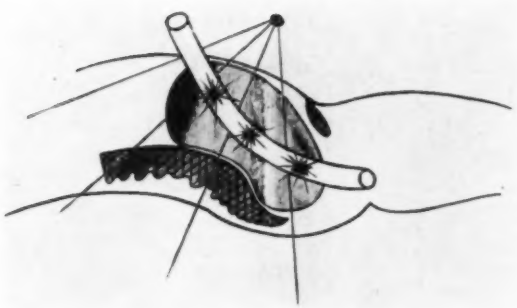

FIG. 1.—Perforated drainage tube to allow; (1) repeated introduction of radium; (2) drainage of poisonous by-products (cachexia); (3) direction of least resistance for the pressure incident to growth; (4) lymph to go out through the tumor instead of back into the system; (5) the periphery of the tumor to constantly approach the radium.

But neither Bland-Sutton nor the other authorities give satisfactory instances, and none, with the possible exception of Hofmeier (mentioned by Pfannensteil), give any report of the disappearance or retrogression of true adenocarcinoma.

The following five cases which have come under my personal observation seem to me worth reporting, as the pathologic specimens are all preserved in the laboratory of the Massachusetts General Hospital:

CASE I.—E. S. Records, vol. 372, p. 76. A woman of thirty-two was operated on by my chief, Dr. F. B. Harrington, at the Massachusetts General Hospital on June 30, 1900. Under the diagnosis of pelvic abscess an incision was made in the vagina, some papillocystic material was curetted out and drainage established. Nine days later, at Doctor Harrington's suggestion, I opened the abdomen and found a large inoperable pelvic mass, and diffuse wart-like metastases scattered over the whole peritoneum.

From year to year this patient returned to the hospital seeking radical operation and was considered hopeless by the various surgeons to whose services she was admitted. The vaginal sinus persisted and discharged pus and occasionally lumps of necrotic malignant tissue. Although the tumor grew, her general condition improved.

Finally, on December 22, 1910, ten years after the original operation, I was persuaded to attempt another. To my surprise, on opening the abdomen, I found the peritoneum perfectly free from metastases and the growth limited to the huge pelvic tumor which was adherent to the neighboring structures. After a sort of nightmare operation, I succeeded in removing the entire tumor with all the pelvic organs, including the rectum. An artificial anus was made. After a tedious convalescence the patient recovered, and when last seen on August 14, 1916, was fat and well—six years after the second operation and sixteen after the first.

All pathologic specimens showed typical papillary cystadenoma. The large tumor was more solid than cystic.

CASE II.—E. S. Records, vol. 664, p. 327. A negress, aged twenty-three, was operated on by me at the Massachusetts General Hospital on December 9, 1909. An inoperable pelvic tumor and numerous peritoneal metastases were found. A specimen was taken from the peritoneum and reported to be adenocarcinoma. No attempt was made to remove the tumor. She made a good recovery, and in June, 1916, her physician reported that she was well and had since married. A small pelvic tumor still existed—six and one-half years after the first operation.

On May 27, 1918, her physician, Dr. C. P. McClendon, of New Rochelle, N. Y., wrote: "I have just returned home and found your letter making inquiry about R. M. I am happy to state that she is in very good health. And the trouble of which she complained when I last wrote to you seems to have subsided. She seems to be in excellent health. She is sometimes troubled with periods coming on twice a

month, but seldom complains of the sharp pains as she used to. She is not willing to be operated and so I just look her over at odd times."

CASE III.—Codman Hospital Case 270. July 22, 1915. Female, aged sixty-two years. An abdominal tumor larger than full-term uterus. Pre-operative diagnosis—ruptured papillomatous cyst of ovary.

Operation (E. A. C. and A. R. Barrow).—Large multilocular cyst. It had been ruptured to some extent, and the jelly-like contents had spread about abdominal cavity and in places had become encysted again. The tumor was removed and was found to consist of numberless spaces filled with colloid material, but there were no papillomata—only thin walls. Nevertheless, on section, Dr. J. H. Wright considered the specimen colloid cancer.

Complications.—None.

May, 1918: Her physician reports by telephone that there is no sign of recurrence.

CASE IV.—Codman Hospital Case No. 308. March 13, 1916: Female, aged fifty-five years. Abdominal tumor extending from pelvis 2 inches above umbilicus. Pre-operative diagnosis—fibroma of uterus, or cystoma of ovary.

Operation (E. A. C. and A. R. Barrow).—Tumor proved an extensive malignant mass involving all pelvic organs and invading peritoneum with little tubercles. Piece of peritoneum excised and reported adenocarcinoma (psammoma) by Doctor Wright. Condition considered inoperable and abdomen closed.

On reflecting on this case, it occurred to me that as the tumor was evidently partly cystic, it might be possible to obtain through-and-through drainage, and to treat the tumor with radium from inside out, through the pathway thus obtained. The patient's relatives were, therefore, sent to consult Dr. H. A. Kelly of Baltimore, Dr. John G. Clark of Philadelphia, Dr. Francis D. Donaghue, and Dr. R. B. Greenough of Boston, to see whether such an operation would be justifiable, and it was advised that the attempt should be made, although no precedent existed.

On March 22, I operated again and carried a large rubber tube through the mass from the abdomen out through the vagina. By introducing radium (obtained through the courtesy of the Huntingdon Hospital) through this tube, a thorough course of treatment was given.

To my great astonishment the bulk of the tumor vanished, so that at the time of her discharge on July 29th, there was only a small pelvic mass left. From being almost moribund, her condition had become one of almost perfect health.

After this she received several external radium treatments at the Huntington Hospital (No. 16,148) which were unfortunately followed by a severe burn of the abdominal wall, from which she suffered a great deal.

On March 21, 1917, she re-entered for treatment of the radium burns, which proved so intractable that I decided to excise them. At this time her general condition was excellent, and the only remains of

the original tumor was an irregular pelvic mass occupying about half the pelvis.

Operation (April 10, 1917) (E. A. C. and G. A. Leland, Jr.).—The burns were excised and the abdomen opened. The pelvic mass seemed operable, and after a five-hour operation, I succeeded in removing it with the uterus and adnexa. To my great surprise the peritoneum now showed no trace of disease, and the uterus and its adnexa, which previously were indistinguishable in the cancerous mass, were now plainly recognizable, although adherent. The disease seemed wholly confined to the ovaries, which measured 7½ x 6½ x 4 cm. and 8 x 6½ x 5 cm., respectively. Vaginal drainage was established, and the abdominal wound was closed. The appendix, which contained a concretion, was not removed. Microscopic examination showed that the ovarian tumors resembled the original tumor, but the cells showed no mitoses. In the abdominal scar a few small areas of disease were also found.

Complications.—An abscess in the abdominal fat and a very small rectovaginal fistula.

Result (May 15, 1918).—The patient is well and has gained much flesh. There is no evidence of recurrence. She still has some trouble with a second small radium burn which appeared six months after the last radium treatment.

It is interesting to note also that a small pedunculated fibroid tumor which was present at the first operation was removed at the last operation. It showed no apparent change in size, in spite of the energetic radium treatment.

I attribute the favorable outcome in this case to the following factors:

1. The tumor could be treated from within outward.
2. The calcareous deposits by the cancer cells indicated that there was a tendency towards replacement of cancer tissue with lime salts.
3. The calcareous atoms could set up secondary radiation.
4. The toxic products of destruction could be drained away.
5. The patient had already shown that she could develop a very large malignant tumor without producing general cachexia.
6. The patient herself showed indomitable optimism and courage.

Case V.—Codman Hospital Case No. 408. Female, aged sixty-three years. An abdominal tumor the size of a six months' uterus.

Operation (August 28, 1917) (E. A. C. and H. V. Andrews).—Free brownish peritoneal fluid. Tumor mass adherent in pelvis, partly cystic and partly solid. Peritoneal metastases—some even as high as right renohepatic region. Cysts evacuated and partitions broken down so that rubber tubes could be placed for the use of radium. Both ovaries probably involved.

Post-operative treatment with radium as in Case IV.

May 31, 1918. Patient is well and strong, although an irregular pelvic tumor is still present with sinuses through which radium treatment is occasionally given.

The section shows papillary adenocystoma of the usual type.

Although this patient has been only nine months since the operation, I consider her progress excellent and plan to do the second operation in a few months, hoping to find, as in the other cases, that the peritoneal involvement has disappeared.

NOTE.—Since reading this paper I have again operated on Case V. As in Case I and Case IV the effect of drainage (and perhaps also of the radium) had been to localize the tumor and to render it operable. As in the other cases I removed the tumor en masse with the uterus and adnexa. Like the specimens in these cases, this one also showed that the mass had shrunk and become solid .

Unfortunately in this case the peritoneal metastases had not wholly disappeared, although on the right side of the abdomen they had greatly diminished in quantity. Deep in the pelvis they had apparently increased and were present in the muscular coats of the rectum and sigmoid. Nevertheless I believe these were local implantation metastases and that after removal of the main mass and continued radium treatment there is a real hope that they may disappear. In spite of this difficult operation the patient had a rapid convalescence.

The progress of this case, which was treated on a definite plan, seems to me most encouraging, when one contrasts it with the probable outcome of cases treated without drainage as shown by the thirty-nine cases mentioned in the text.

In order to have some idea of what the usual outcome of such cases is, I determined to try to trace all similar cases which had been operated on at the Massachusetts General Hospital in the last twenty-five years. This privilege was granted me by the gracious consent of my former colleagues at that hospital. I found 41, excluding all cases which died in the hospital after operation, and all cases in which the records did not give what I considered adequate proof of the existence of a malignant or papillary peritonitis at the time of operation, and also my own cases. I succeeded in tracing all. (This speaks pretty well for the records of the Massachusetts General Hospital, I think.)

All but two of these 41 cases died of the disease. These two were of the colloid type—one living at least nine years and the other over four years. One of the colloid cases is worth recording.

Massachusetts General Hospital. E. S. Records, vol. 546, p. 165. Operation by R. B. Greenough, August 20, 1906. The peritoneal cavity was filled with greenish jelly-like substance. A large multilocular cyst was removed and a hernia, following a previous laparotomy, was repaired. Several small cysts filled with jelly-like substance were found in the scar tissue. The pathologic specimen showed the characteristic appearance of colloid carcinoma even in the abdominal scar. The abdomen was washed out with weak soda solution as thoroughly as possible. Patient had an uneventful convalescence.

January 22, 1907, she re-entered the hospital, stating that she had been comfortable until four days before, when pain, suggestive of gall-

stones, occurred. There was a mass the size of an orange in the right hypochondrium which was exceedingly tender. She was operated on by Dr. F. B. Harrington who found the "peritoneal cavity largely obliterated by adhesions and soft gelatinous tissue; liver completely hidden by these adhesions. Gall-bladder not found and search not persisted in. Bit of omentum and gelatinous tissue removed for pathologist" (reported inflammatory).

Patient had complete relief from her pain and normal convalescence.

She again entered the hospital on December 11, 1915, having in the meantime been operated on at the Boston City Hospital, under a diagnosis of intestinal obstruction. We were informed that at the laparotomy dense adhesions were found about the liver and gall-bladder could not be located.

She now complained that for the last month she had had attacks characteristic of gall-stones and again had tenderness in the right upper quadrant. On December 18, 1915, Dr. D. F. Jones operated and found dense adhesions, but there was no mention in the report of gelatinous material. Some small stones were removed from the gall-bladder. She had a normal convalescence.

On January 7, 1917, she reported as being partially relieved.

I have been told by Dr. R. B. Greenough that she has recently had another operation for ventral hernia.

It seems to me that this case shows evidence that the presence of colloid material, such as found at the second operation, does not necessarily mean hopelessness. Unfortunately, the bit of omentum excised was not a satisfactory proof of the existence of epithelial cells at that date.

The others died at the following periods: Of the total, 39, 12 died in less than two months after operation; 19 died in less than six months after operation; 29 died in less than one year after operation; 33 died in less than two years after operation; 39 died in less than four years after operation. In other words, 30 per cent. died in less than two months and 74 per cent. in less than a year. These are rough figures but are conservative. They show that as a rule the condition is rapidly fatal.

We may conclude from this that such cases usually die within a year after coming to operation. All of the 41 were operated by competent surgeons, most of them members of this Society. However, my own five cases seem to show beyond doubt that the peritoneum has the power to kill and replace cancer cells under certain conditions. The observations made in these cases have led me to indulge in some speculations in regard to cancer in general, which may be of interest to you.

How does cancer kill? In a general way (1) by erosion, as in the case of a rodent ulcer which actually eats its way into a vital structure. This is rare. How few cases any one of you can actually recall! (2) By perforation of a vital structure, as of the stomach or intestine. This is more common but still rare. A preperforative sealing process usually prevents it. (3) By stricture of some vital organ, as in the case of obstruction of the intes-

tine. Even this is amenable to timely surgery. (4) By mere bulk causing pressure on some vital structure, as in the case of extensive disease of the lungs. (5) By cachexia. This you will admit is the common cause, and usually the precursor of the other causes. To be sure, occasionally one sees a case die from erosion of a great vessel, from the perforation of a viscus from occlusion of the intestine of ureters, or from intracerebral pressure, before any cachexia has appeared, but you must agree that in the vast majority of cases there is also a severe cachexia present. And will you not agree also that if we could prevent cachexia, we could prolong many lives indefinitely, and also cope fairly well with these other more mechanical conditions of erosion, obstruction, perforation and pressure, which we handle after a fashion as it is?

What makes metastases? It is a platitude to remind you that cancer tends to grow. If the growth is under pressure in the interior of the body, is it not more likely to metastasize than if it is external? External cancers may last for years and give rise to no cachexia whatever. The two most benign forms of cancer are rodent ulcer and papilloma. In the one case the cells soon lose their vitality when exposed to the air and are wiped off by any light friction. In the other they grow outward in grape-like clusters, but in neither case do they cause cachexia or metastases, until their base has invaded the subsoil. In other words, the poison which would be absorbed by an internal growth is drained off and the internal pressure of the growth goes outward, sloughing off in the rodent ulcer, and hanging free in papilloma. Observe that papilloma is a typical growth in the hollow viscera—of the bladder, of the intestine and sometimes of the stomach. Histologically it is hard to tell whether it is benign or malignant in a given case. I believe the answer in each case could be given if we knew the direction of lower mechanical pressure in the deepest cell. This would determine whether the next cell would be cast off into the outer world or into the lymph- or blood-stream. If the latter, it would mean danger of metastases and cachexia. If the former, it would mean freedom from absorption of the poison or spread of the disease.

Now how about the ovary? Here we have papillary cystadenoma as the type tumor. Cysts develop with papilloma in them. The growth is hardly external or internal. Though inclosed, the direction of least resistance is toward the peritoneal cavity. Cysts form faster than their papillomatous contents. While this goes on they are benign. When the solid cellular part gets the upper hand they become malignant. When the growth of a papillary cystadenoma adding cell by cell reaches a certain point of tension from internal pressure, some cells are forced through the fibrous envelop and protrude on the peritoneal surface. As these little tumors add more cells, their terminal ones drop into the free peritoneal cavity, lodge and take superficial root. They become peritoneal metastases. Sometimes this process is rapid, because some external trauma ruptures the cyst and the cells are seeded through the whole peritoneum.

In other cases the peritoneal metastases are rather of the nature of direct extension of tumor cells along the peritoneal lymphatics, and are seen as minute whitish tubercles radiating from the pelvic peritoneum upward. Such cases are true adenocarcinoma if I may judge by Cases II and IV. In others, colloid spaces are found in the meshes of the omentum or smooched into the interspaces of the intestines. But in all of these three kinds the peritoneum indubitably may triumph.

We know the wonderful power the peritoneum has in dealing with sepsis and with tuberculosis. Who has not marvelled at seeing the smooth shining surface of the peritoneum, in some case, at a second operation, which a few weeks earlier he saw red and turgid with an angry inflammation? And the return to normal after severe tuberculous involvement is now almost expected. I believe that you may also look for such results in a small proportion of your malignant cases. If my experience has met so many, surely the fact must be that other such happy results are occurring at other clinics, if the cases be followed up.

Is my own lucky experience due to my treatment in any way? Case I made me feel that drainage was perhaps the cause. It suggested that furnishing a direction of least resistance and permitting free drainage might prevent metastases and cachexia. Case II showed the tendency of nature in exceptional cases to do much unaided. Case III showed the value of hope when artificial drainage, nature and radium were united to do their best with one object in view. Surgery acted a subordinate part in two cases (I and III) by removing what the other agents had localized. Case V is bearing out my theories. She has no cachexia.

Fig. 1 is offered to show you in a glance how my present ideas of the proper treatment are summarized.

In conclusion let me set down these facts and principles, for I believe the observations made in these cases justify them.

Facts.—1. The peritoneum has a special power of resistance and repair after diffuse infection with septic organisms or tubercle bacilli, and in a minor degree, after diffuse invasion with cancer cells of ovarian origin.

2. It is possible for nature unaided to cause the retrogression of peritoneal metastases and the gross limitation of a diffuse malignant condition into operable tumors.

3. Radium, which is known to be the most efficacious in those new growths which are clinically most benign, may also aid the peritoneum in a battle which otherwise is only slightly in favor of the growth.

Principles.—1. The most malignant characteristics of cancer are: (*a*) Its insistence on growth. (*b*) Its absorbable poison which produces cachexia. (*c*) Its tendency to metastasize. Beyond these three mysterious characteristics it has only mechanical terrors. Even these mechanical terrors would be controllable to a large extent by ordinary surgery, for we can do plastics on erosions, suture perforations and remove mass pressure.

2. Therefore, the treatment of cancer in general should aim at (*a*) providing a direction of least resistance for the growing cells, and at conducting the growth toward a point at which we can bring its enemy, radium, to meet it, (*b*) at maintaining the fluid lymph-flow from the rest of the body out through the malignant tissue, so that the cachetic poison will be released instead of being absorbed; (*c*) preventing metastasis by intelligent attention to the pressure exerted by growth in the deepest cells.

3. Ovarian malignant disease lends itself peculiarly to this treatment because it is papillomatous in type, has a large fluid draft, and clinically is known to have a mild cachexia and a low metastasizing power, also normal ovarian tissue is known to be especially sensitive to radiant energy.

I hope that when you next run across one of these hopeless cases, you will at least give these theories of treatment a trial. Personally, I believe they form rational principles for the treatment of cancer in general.

TRANSACTIONS
OF THE
PHILADELPHIA ACADEMY OF SURGERY

Stated Meeting, held April 4, 1918

The President, Dr. Edward Martin, in the Chair

TREATMENT OF GUNSHOT FRACTURES OF THE MANDIBLE

Dr. John B. Roberts read a paper with the above title, for which see page 245.

Dr. Hunter W. Scarlett said that during two and a half years at the Ambulance in Paris, there were treated many gunshot fractuers of the jaw and face, and he was enabled to follow several of these cases. He then showed a series of pictures of two cases, in which there was extensive loss of bone and soft tissue and with no possibility of retaining bone fragments or of applying splints. In the first case, after thorough cleansing and removal of foreign material from the wound, the tissues were approximated as nearly as possible to the normal. When the scar tissue contracted to the utmost, and the time for operation arrived, they excised the scar, dissected back the flaps and approximated the soft tissues. After that the dental surgeon took charge of the patient. The benefit derived from the plates which he inserted was quite marked. In the beginning of the treatment of the case it was, of course, necessary to feed the patient by a tube through the nose. After the plate was made, the man was able to chew with a certain amount of comfort.

In the second case, in which the fracture was received just inside the angle of the jaw, reduction was made before the patient came to the hospital. The pictures show the great amount of mutilation of the soft tissues and the result obtained by simply excising the scar tissue, dissecting the flaps well back, and approximating the two edges.

Dr. George P. Müller noted that in the gunshot injuries of the jaw encountered in the War, hemorrhage is an occasional complication, and contrary to experience in civil surgery comes from the distribution of the lingual artery in the majority of cases.

Dr. Penn G. Skillern, Jr., with reference to the relation of silver wire to necrosis of the jaw, said he thought that silver wire should be discarded in favor of an animal suture, such as kangaroo tendon. Sutures of this type placed in the mandible are not as irritating as silver wire and yet possess sufficient tensile strength, particularly if the tendon knots are reinforced by catgut suture knots, since the kangaroo tendon knot is very liable to slip. War fractures of the mandible are accompanied by greater loss of substance than the fractures encountered in civil life; in fact, a gap

in the mandible results in a large proportion of the cases. The majority of ununited gunshot fractures occur on the lateral aspect of the mandible and exhibit a gap rarely exceeding 3 cm. in length. He did not think sufficient emphasis had been placed upon the value of bone grafting in mandible injuries. In his opinion a bonegraft forms the most satisfactory splint for fractures of the mandible with breach of continuity. While most of these fractures are compound yet the bonegraft resists infection sufficiently long to justify its use, especially if inserted after the acute infection has been controlled. It encourages reproduction of bone on the part of its host and acts as a scaffolding. The proper distance of the fragments from one another can be maintained with the "shoulder graft"—a bonegraft provided with a couple of shoulders, which abut against the ends of the fragments and maintain their proper relation to the gap. The ends of the graft are fitted into gutters developed in each fragment and retained by kangaroo tendon sutures passed through drill holes and around the graft. Autogenous bonegraft screws give better fixation and he uses them in preference to kangaroo tendon because they make the graft mchanically a part of the mandible. The autogenous bone screws are passed through the graft into the mandible, and if the infection is controlled, as is now rendered more quickly possible with chemicals like dichloramine-T, which can be used in the mouth when dissolved in the non-irritating chlorcosane, the mandible in favorable cases will proliferate bone across the gap, guided by the graft

Destruction of the chin can be remedied by cutting a U-shaped graft from the upper portion of the tibia, the apex of the U corresponding to the tibial tubercle, which by its smoothness and prominence forms an excellent chin. This graft is then transferred to the mandible and secured to the margins of the defect.

Destruction of the central portion of the mandible also can be remedied by a U-shaped graft, made larger than that for the chin, according to the extent of the defect. The graft ends are fastened on each side to the body ends.

Destruction of the body and part of the ramus of one side can be remedied by cutting an L-shaped graft from that portion of the tibia which extends from the inner surface of the internal tuberosity of the tibia downward and forward to include part of the tibial crest: by kangaroo tendon sutures placed through drill holes the crest portion of the graft is secured to the stump of the ramus, and the tuberosity end to the symphysis end of the sound side of the mandible. Platt, Campion and Rodway (*Lancet*, March 30, 1918, 461) report nine cases of mandible injury in which tibial bonegrafts were implanted successfully. Cole (*loc. cit.*, 459) describes a novel pedicled graft method in the treatment of ununited mandible fractures.

As to the source of the graft, that taken from the antero-internal surface of the tibia high up seems to work better than a graft from any other bone: some, however, use the rib near the angle for this purpose; others, the crest of the ilium.

Dr. Edward Martin said that he had taken some pains to ask dental surgeons in what way the general surgeon should coöperate with them in preparing the field for the really skilful technician. They advise first to fix in a position of good occlusion; to preserve the space between the lips and cheek to prevent dribbling; to employ, if we have it, the moulded splint containing the dentist's moulding wax. They advise against wiring or, on the part of the unskilled, an attempt at plaster-of-Paris work.

In regard to the wiring of which so much has been said, he asked an expert man to wire for a demonstration for his class a broken jaw made by a rifle bullet. In reply to his inquiries he said it would take him about an hour to do the work, and an inexperienced man three hours; further, that the fixation when done would not last. In view of this he asked, is it any use to teach men who are not expert the art of wiring? Do the dentists do it?

Dr. Gaskill (replying to Doctor Martin) said that wiring the mandible for fixation is the simplest form of splint. It can be done in a short time, and if the wire is sufficiently strong the fixation may last almost indefinitely. It is quite a simple matter.

ACUTE PANCREATITIS

Dr. John B. Deaver read a paper with the above title, for which see page 277.

Dr. George P. Müller asked Doctor Deaver if he ever attempted to get rid of the necrotic mass at the head of the pancreas. It is hard to understand how an incision in that necrotic, hemorrhagic mass can afford drainage. Doctor Deaver also spoke of waiting until there was recovery from shock. He wondered if he would not rather put it that energetic measures should be speedily adopted against shock? The probabilities are that the patient will not recover from shock while he has the pathology. Doctor Deaver will remember that in 1904 they read a joint paper on acute pancreatitis. He did not believe that except for improvements in operative technic that knowledge of this disease has been much advanced since that time.

Dr. Deaver, in conclusion, said that in a small percentage of acute pancreatitis he has found that pain was referred to the left shoulder and back. He used gauze packing for stopping the bleeding and drainage, which he allowed to remain in place until it became loose. He also stated that in bleeding after incising the necrotic pancreas if the gauze packing did not suffice he was usually able to check the flow of blood by through and through catgut suture.

CORRESPONDENCE

SKIN ASEPSIS IN SURGERY

To the Editor of the Annals of Surgery:

Sir:

Doctor O'Conor, in a letter to you published in your issue of April, 1918, draws attention to a fact which should, I think, be more widely known than, judging by the practice of many surgeons, it appears to be. I refer to the passage in his letter in which he says, "I feel convinced that disinfection of the skin of the abdomen by tincture of iodine is a most dangerous procedure; and I regret to have to state that, in some of my cases, it has proved itself to be a veritable death trap." It is more than six years ago that I drew attention to the risks run by the adoption of this method of sterilizing the skin of the abdomen prior to opening the peritoneal cavity. (See "Practice and Problem in Abdominal Surgery," p. 67.) In support of the opinion therein expressed, I cited some experiments on dogs by Propping (*Zentralblatt fur Chirurgie,* Nos. 19 and 26) who showed how readily adhesions formed when iodine was applied to the surface of the peritoneum. M. H. Walker and L. M. Ferguson (Annals of Surgery, February, 1916), experimenting on rabbits, also demonstrated the dangers dependent on the contact of the drug with serous surfaces, and expressed their opinions in these words: "Iodine should be used in abdominal surgery with great care, or better not used at all, for a very little of it allowed to touch the bowel causes masses of adhesions." I sought again to draw attention to the subject by a short contribution to the *British Medical Journal* in 1916 (vol. xi, p. 75), feeling that it was of sufficient gravity to warrant a wider recognition than it yet seemed to have received. The use of iodine has become so general in application as a pre-operative means of sterilizing the skin that the danger of its use in certain individual cases is still overlooked; and with too little regard for the importance of the matter, many surgeons are so satisfied with present results that they lose sight of the possible ills which the future may reveal. It is with the hope of not only further ventilating the possible deleterious effects of this dangerous practice, but of drawing attention to actual facts recorded by Doctor O'Conor —so much more forcible and convincing than mere expressions of opinion— that I have ventured to address you on the subject. There are many other ways of efficiently sterilizing the skin without endangering the peritoneal surfaces; and I am old-fashioned enough still to cling to Listerian practices by using carbolic lotion in strengths of 1 in 40 and 1 in 20. The former is applied as a wet compress for twelve to twenty-four hours before the operation (when time will allow) and the latter for an hour prior to making the incision. In cases of urgency, the 1 in 20 strength is alone used.

A. Ernest Maylard.

Glasgow, June 25, 1918.

SIMPLIFYING CEREBRAL LOCALIZATION

To the Editor of the Annals of Surgery:

A number of methods for locating the fissures of Rolando (central) and Sylvius have been described in the text-books, the simplest being those of Kronlein and Kocher. They are all more or less open to objection, being complicated, owing to the efforts of their originators to consider the cranium and its contents from a mathematical standpoint.

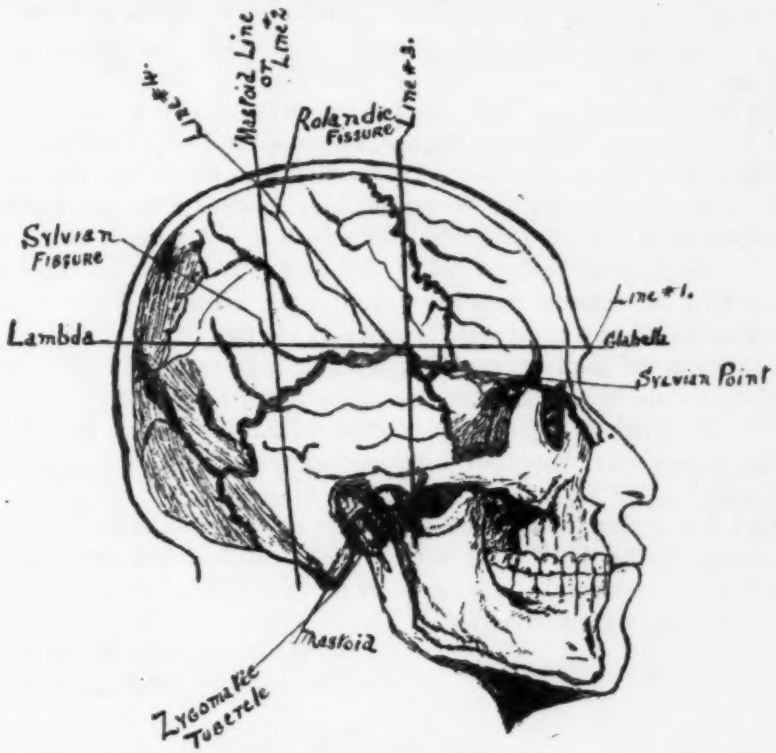

Fig. 1.—Lines for cerebral localisation.

In text-book descriptions instructions are given to locate certain points by measuring fixed distances from other points and then run lines at fixed angles, or what is worse, one is instructed to use a certain number of degrees from the perpendicular which necessitates the use of some form of instrument. This is all very confusing and tends unnecessarily to complicate matters because all crania are not of the same size or outline, hence, it follows that no one mathematical formula would fit all cases even were it simple.

The following method has been found useful and is simple in that it requires no measurements or mathematical processes. It is based on bony landmarks of the skull which are easy of location and it will be found that most brains occupy the same relative positions to these landmarks.

The osteoplastic flap being the method of choice in the great majority of brain operations insures that this method will be found sufficiently accurate. In any analysis it will be found to be much more accurate than any mathematical method.

The method requires four lines run from five landmarks. First, a line from glabella to lambda. Second, a line perpendicular from the posterior part of the mastoid to the sagittal suture. Third, a line perpendicular from the tubercle of the zygoma to the sagittal suture. Fourth, an oblique line connecting the junction of the zygoma-glabella-lambda lines with the junction of the mastoid-sagittal suture lines. This oblique line will practically cover the central or fissure of Rolando (see Fig. 1).

The Sylvian point may be located in two ways: First, it lies almost beneath (and for practical purposes may be considered to do so) the tip of the greater wing of the sphenoid at its junction with the frontal and parietal bones. Second, a line drawn perpendicularly upward from the middle of the zygoma until it meets the glabella-lambda line will cover it at the latter junction. If the glabella-lambda line is followed from this junction to its junction with the mastoid-sagittal suture line the fissure of Sylvius will be outlined with sufficient exactness for any surgical purpose.

In addition, the line from the tubercle of the zygoma to the sagittal suture almost covers the course of the anterior branch of the middle meningeal artery. The artery being slightly anterior below the glabella-lambda line and slightly posterior above, but in no part being more than a quarter of an inch distant.

There is a saying that "There is nothing new under the sun," and this method may not be, but I have been unable to find such a description in anything at my command. It is certainly much simpler than anything commonly described in the text-books.

F. W. RINKENBERGER, M.D.,
Seattle, Wash.

July 2, 1918.

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